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ADVISORY GROUP FOR AEROSPACE RESEARCH & DEVELOPMENT
7 RUE ANCELLE, 92200 NEUILLY-SUR-SEINE, FRANCE

AGARD CONFERENCE PROCEEDINGS 554

Recent Issues and Advances in Aeromedical Evacuation (MEDEVAC)

(les Progrès récents et les questions posées dans le domaine de l'évacuation aéromédicale (MEDEVAC))

Papers presented at the Aerospace Medical Panel Symposium held in Athens, Greece, from 3rd to 7th October 1994

NORTH ATLANTIC TREATY ORGANIZATION

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North Atlantic Treaty Organization

Organisation du Traité de l'Atlantique Nord

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According to its Charter, the mission of AGARD is to bring together the leading personalities of the NATO nations in the fields of science and technology relating to aerospace for the following purposes:

— Recommending effective ways for the member nations to use their research and development capabilities for the common benefit of the NATO community;

— Providing scientific and technical advice and assistance to the Military Committee in the field of aerospace research and development (with particular regard to its military application);

— Continuously stimulating advances in the aerospace sciences relevant to strengthening the common defence posture;

— Improving the co-operation among member nations in aerospace research and development;

— Exchange of scientific and technical information;

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Preface

This Symposium addressed a topic of ever-increasing importance — the International Aeromedical Evacuation of acutely ill and injured patients.

In both military and civil communities, there is much discussion which seeks to clarify NATO's role in medical air evacuation during humanitarian, peace keeping and disaster efforts as well as in wartime.

Papers in this Symposium updated available data in medicine research and development and provided a focal point for discussion of specialized equipment and techniques required to care for patients in the NATO MEDEVAC SYSTEM.

The lectures focussed on interoperability, coordination and standardization as there is a clear operational need to form a generic concept of integrated Aeromedical Evacuation.

Préface

Ce symposium a examiné un sujet d'une importance croissante, à savoir l'évacuation sanitaire internationale par voie aérienne de patients blessés et gravement malades. A l'heure actuelle, de nombreuses discussions sont en cours au sein des communautés militaires et civiles, dans le but d'élucider le rôle de l'OTAN dans l'évacuation sanitaire des malades et des blessés lors des opérations humanitaires, maintien de la paix et catastrophes naturelles, ainsi qu'en temps de guerre.

Les communications présentées lors du symposium ont permis de faire le point sur l'état de l'art en R&D médical dans ce domaine. Elles ont fourni la base des discussions qui ont eu lieu sur les équipements et les techniques spécialisés nécessaires aux soins à apporter aux malades dans le cadre du système MEDEVAC de l'OTAN.

Les conférenciers ont mis l'accent sur l'interopérabilité, la coordination et la standardisation, étant donné le besoin opérationnel manifeste d'un concept générique d'évacuation sanitaire intégrée.

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Technical Evaluation Report

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1. SYMPOSIUM

RECENT ISSUES AND ADVANCES IN AEROMEDICAL EVACUATION (MEDEVAC) 04 - 06 Oct. 94, Athens, Greece.

2. INTRODUCTION

In this three day meeting 26 papers and an invited Keynote Address representing 9 NATO nations constituted the scientific program which included a technical tour.
Significant to this meeting were the attendance of official delegates from SHAPE, CHIEF MED HQ ARRC and CAPC. Also of significance were the registered participants, which exceeded 150.

3. THEME

Recent experience has demonstrated NATO's difficulty in planning and coordinating INTERNATIONAL AEROMEDICAL EVACUATION of acutely sick, injured and wounded patients. As a result in both the military and civil communities, there is discussion which seeks to clarify und define NATO's role in medical air evacuation during humanitarian, peace-keeping and disaster relief efforts as well as in wartime.

Papers in this symposium have updated available data in medicine, and in research and development in the field of AEROMEDICAL EVACUATION.

4. PURPOSE AND SCOPE

The PURPOSE of this symposium was to exchange data, experience and management rationales dealing with the very sophisticated task of AEROMEDICAL EVACUATION. Such exchange would also facilitate the discussion on how to provide the specialized equipment and techniques required to care for patients in the NATO MEDEVAC SYSTEM. The goal was also to develop a series of recommendations that would directly address the deficiencies in AEROMEDICAL EVACUATION identified during the course of the meeting.

The SCOPE of this symposium was broad covering the role, training, procedures, as well as command and control in the management of casualties in the aeromedical evacuation system. The lectures focused on interoperability, coordination and standardization to benefit further planning for multinational operations.

5. SYMPOSIUM PROGRAM

The Symposium consisted of a Keynote Address on the ADVANCED TRAUMA LIFE SUPPORT (ATLS) by Prof. Dr. J. Androulakis, University of Patra, GR and six scientific sessions which were chaired as follows:

a)	SESSION I	The Medevac Experience in Airborne Operations
	Chairmen:	Col Dr. E. Rödig, GE and Col R.E. Landry, US
b)	SESSION II	Medevac Transfer of Casualties: Preparation and Coordination
	Chairmen:	Col R.E. Landry, US and Dr. J.P. Landolt, CA
c)	SESSION III	Medevac Transfer of Casualties: Converted Air Carriers and Hospital Ships
	Chairmen:	Dr. J.P. Landolt, CA and Col T.S. Johansen, DE
d)	SESSION IV	Medevac Transfer of Casualties: On-Board Aircraft Special Care Equipment
	Chairmen:	Col B. Voorsluijs, NE and Maj F. Rios-Tejada, SP
e)	SESSION V	Combat Casualty Care in the Air
	Chairmen:	Col T.S. Johansen, DE and Col B. Voorsluijs, NE
f)	SESSION VI	Combat Casualty Care Providers
	Chairmen:	Maj F. Rios-Tejada, SP and Dr. J.P. Landolt, CA and Col Dr. E. Rödig, GE

The Session Chairmen and Captain R. Hain,US formed the Technical Programme Organizing Committee.

6. TECHNICAL EVALUATION

In his Keynote Address, Prof. Dr. J. Androulakis, University of Patra, Greece, spoke on Advanced Trauma Life Support (ATLS) as a golden Standard for first-hour intensive care. He emphasized the importance of a qualified permanent training in ATLS for those care takers who are involved in the continuing and evolving requirements of a modern rescue system.

6.1. The Medevac Experience in Airborne Operations

National and internationa experience in aeromedical evacuation missions and attempts at defining the innovative steps to resolve evident problems during deployment, set-up and execution stages were addressed in Session I. As Power (Paper #1 by Bloomquist) has pointed out, much effort in medical planning has gone into understanding the wartime requirements and the peacetime needs.

Machinery, man power, proper methodology and financial resources are four main areas which, combined with quality techniques (Theory of Constraints Institute), constitute an Aeromedical Evacuation System; one that ist structured, trained, and equipped to satisfy the needs of the twenty-first century.

Several papers reviewed the intra- and intertheater experience during United Nations Aeromedical Evacuation Operations in the former Yugoslavia (Papers #2, #3, #6, #10).
Ms. Read (Paper #2) reviewed the Canadian experience which included 102 airvac flights. She addressed three main concerns which impact on aeromedical evacuation: command and control, proper equipment and training readiness. She emphasized that interoperability still is a big problem.
Paper #3 (Thornton) was presented by Neubauer.
He examined intratheater aeromedical evacuation of UNPROFOR casualties. The empirical report demonstrated that effective aeromedical evacuation was complicated by several factors. He emphasized the necessity of specifically designed medevac units, medevac assets, standardization of communications and international operations plans, emphasized training readiness and encouraged the establishment of intratheater medevac teams including a flight surgeon. There is a clearly defined evacuation gap between first aeromedical units in the field and the third echelon field hospitals.
In Paper #6 (Navarro), presented by Sanchez, the authors discussed the conflicting medevac issues identified in a multinational forces scenario from a theoretical and practical standpoint.
In conclusion, he analysed the same deficiencies as the speakers before and proposed guidelines to improve the current situation. The advocated close cooperation and collaboration between Dutch civil aeromedical evacuation expertise and RNLAF evacuation personnel in repatriation flights all over the world were discussed in paper #4 (Rutten).

In peacetime as in war, patient stabilization on the spot is not always possible. However, the highest standards in civil and in military medevac situations are required to accomplish the mission.
In this context, van der Meulen (Paper #5) presented an Aeromedical Evacuation Protocol by the RNLAF to minimize the risks for Medevac patients. In addition, Navarro (Paper #6) staxted that current warfare creates an ever-changing situation, in which new weapon systems and technological advances have not only made war, but also medicine more complex. Consequently, he called for more agressive policies and guidelines for Air Medevac of combat casualties.

Regarding the problem of helicopter airvac in emergency pre clinical service in Madrid, Cepas Vasques (Paper #7) noted the importance of a helicopter rescue system. He also noted, however, that over three years, 3272 rescue missions were carried out, of which 1106 were medically not indicated.

6.2 Medevac Transfer of Casualties: Preparation and Coordination

The cornerstone for Session II was set by paper # 8 (Belihar) which was presented by Saboe. The principles and challenges of how to provide aeromedical evacuation in a combined operation were defined.

Danish aeromedical evacuation efforts during the Gulf War with a modified Boing 737-300 (Lyduch, paper # 9) and Spanish experience in the former Yugoslavia (Sanchez; paper # 10) showed clearly the need for international solutions in air transport capacities for critically ill, sometimes unstable, patients.

These operational requirements are based on the fact that it is not sensible for nations to compete for Aeromedical Evacuation in a multinational theater of operations.

Frank (paper # 11) discussed U.S. Transportation Command's (US TRANSCOM) efforts to regulate global movement for worldwide intertheater aeromedical evacuation. Working closely with all levels, US TRANSCOM's Surgeon is developing TRANSCOM's Regulating and Command and Control Evacuation System (TRAC^{2}ES). It provides three major data pieces: patient information requirements, receiving medical treatment facility capability and patient transportation capability.

In her presentation Ms Fonne (paper # 12) dealt with the impact of occupational differences in air rescue crewmembers which could interfere with the mission. With regard to medical treatment and evacuation (paper # 13), Lynch noted the importance of a sustainment training priority. Habitual training and support relationships are necessary in peacetime if they are to be effective in missions.

6.3 Medevac Transfer of Casualties: Converted Air Carriers and Hospital Ships

Nielsen (paper # 14) explained a different Danish approach to airvac transport utilizing standardized ambulances which are driven onboard a C-130 Hercules, permitting door to door transport. However, this solution is only practicable for individual cases. In this context, a new concept of consolidated container based system for use in the C-130 was introduced.

How to deal with a mass casualty situation was explored by Nistler (paper # 15).

She presented a conversion kit for the Boeing 767, which was certified by FAA for two configurations (111 or 87 litter patients). Medical oxygen and electrical outlets are available at each potential litter position. Civilian airline pilots will fly the Civil Reserve Air Fleet Aeromedical Evacuation Shipsets (CRAF-AESS). 19 complete shipsets out of 44 have been delivered to date.

The prototype UH-60Q Blackhawk with enhanced navigation and communication, and improved access to patients and medical utilities improves US-Army ability to perfom typical Medevac missions . Some components of the medical interior require refinements, however, as Licina stated in paper # 16. Similar results were shown by Schroedl (paper # 17) when he described the capabilities and performance of the CH-53 G as a converted airvac helicopter currently used by the German Army. Due to the shortage of hospital beds Cdr Knutsen presented in paper # 18 the Norwegian approach to convert civilian vessels into hospital ships. So far 17 vessels have been pre-requisitioned. However, cost is a major concern.

6.4 Medevac Transfer of Casualties: On Board Aircraft Special Care Equipment

The four papers in Session IV (paper 23 was cancelled) discussed on-board aircraft special care equipment, its airworthiness and standardization. Paper # 19, presented by Hale, offered the possibility to get access to information on the airworthiness at more than 250 medical devices, for use in the Medevac system environment. The electromagnetic environment of modern aircraft may result in interference if inappropiate electronic equipment is used.

Spencer suggested in Paper #20 that a 'Full Airworthiness Standard' yet to be determined for aeromedical equipment could be the basis for coordination of Medevac equipment scales used by NATO allies.

In paper # 21, Richardson introduced a commercially available transportable pressure ventilator, that is approved for USAF aeromedical evacuation use. It permits the aeromedical evacuation of ventilator dependent patients using any liquid or pressurized oxygen system delivering a pressure of 20 to 50 psi.

The question whether an Onboard Telemetry Equipment should be carried on a Medevac helicopter was discussed by Lynch (paper # 22 by Granger). Based on own experience, he concluded that it is unnecessary and a poor utilization of scarce resources to provide telemetered monitoring of airborne patients in the helicopter evacuation environment.

6.5 Combat Casualty Care in the Air

The analysis of the effect of aeromedical evacuation on clinical outcomes in patients was discussed by Saenger (paper # 24). In the study, 28,199 patients of the CONUS Aeromedical Evacuation System were screened.
There was a total of 26 clinical outcomes reported in 24 patients during this period for a rate of 0.09 %. It was summarized that the adverse clinical outcome rate for AE patients is very low, however "high risk" patients should be followed up by specialists within 48 hours after A.E.
Mild hypoxia in a pressure cabin may adversely affect the oxygen supply of patients whose lung function is reduced.

Christensen (paper # 25) showed in his study that effects of hypoxia on arterial blood gases in subjects with lung dysfunction may occur because of the non-linear shape of the oxygen dissociation curve and the effect of impaired lung function.
The drop in SaO2 was significantly correlated with poor lung ventilation, with low lung diffusion capacity and with the extent of pulmonary shunting. This has to be considered for A.E.

6.6 Combat Casualty Care Providers

Specialized and trained Medevac personnel has proven to have the specific experience and training to perform in the role of in-flight medical attendant. Lyons (paper # 26), evaluated the role of flight surgeons.

In his opinion, the presence of physicians on the crew has distinct advantages. Their understanding of the AE system enables them to provide sophisticated medical coverage of transiting patients. In conclusion he recommended, that agencies with MEDEVAC units should consider assigning flight surgeons to these units.
The necessity of specalized nursing personnel for air evacuated patients was noted by Katsika and Papastogianidou (paper #27). They illustrated the Flight Nurse school in the Hellenic Air Force, which was established in 1988. Apart from education, a primary goal is to integrate the school into the air evacuation system of the Hellenic Air Force.

7. CONCLUSIONS

7.1. Aeromedical evacuation is medically necessary.
It opens the wide scale of sophisticated care at home and guarantees a high standard of medical care in the theatre.

7.2. The new NATO Strategy is characterized by high mobility, more flexibility, rapid argumentation and better interoperability. There is a clear operational need to provide medical planners within NATO and Alliance Nations with a generic concept of integrated aeromedical evacuation to improve the effectiveness of NATO FORCES.

7.3. Any decision to evacuate a patient by air should be made only after a thorough assessment of the medical benefits for the patient as compared to the hazards which might be associated with an evacuation flight. However, there are no absolute medical contraindications to aeromedical evacuation.

7.4. Effective aeromedical evacuation requires:

* dedicated aeromedical evacuation units
* centralized command and control (C^2)
* standardized communications and medical equipment assets
* aircraft with day/night, adverse weather and enhanced navigation and communication capability
* professionalism in the level of proficiency training and experience
* standardized international procedures and policies
* no language barriers
* military-civilian cooperation.

8. RECOMMENDATIONS:

8.1. For future operations the medical authorities within NATO HQ and NATO nations must address the operational requirement for a multinational approach to aeromedical evacuation.

8.2. A multinational generic concept of aeromedical evacuation should be as broad, flexible and simple as possible.

The goal is to provide a framework for NATO nations to plan for effective, seamless aeromedical evacuation in multinational operations.

ADVANCED TRAUMA LIFE SUPPORT (A.T.L.S.)
A Golden Standard for First-Hour Trauma Care

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INTRODUCTION

Trauma is the commonest cause of death and disability in the first four decades of life. These deaths are very frequently due to potentially lethal injuries, "preventable deaths" (5, 20), particularly those during the second peak (20) of the trimodal distribution of trauma deaths. The rate of preventable deaths has been reported from 11 percent to 85 percent. (20).

Although the trauma related costs are in the U.S.A. approximately 40% of health care, less than 4% of governmental research money is spent on trauma. (3). That is why, as the landmark report "Accidental Death and Disability" stated in the 1960's, trauma has been recognized as "the neglected disease of modern society" and the need for improvement in trauma care was strongly advocated. (16).

Three decades later, trauma remains a major health care problem and Thal (18) emphasized that "apathy - lack of feeling or emotion, impassiveness, lack of interest or concern, indifference - is the way society faces trauma care".

In most emergency rooms worldwide, trauma care remains disorganized, inconsistent and fragmented. Until 1980, there was not a standardized program to train physicians anywhere in the world. (3, 10).

In 1978, a prototype Advanced Trauma Life Support Course was tested in Nebraska, a year later was adopted by the American College of Surgeons (A.C.S.) and the following year the A.T.L.S. Manual was published. (3, 10).

Since then, the A.T.L.S. Program for Physicians remains the most dramatic and significant change in the care of the injured patients and is accepted as the golden standard for the first hour of trauma care by all who provide care to the injured at all levels of facilities. (3).

GOALS OF THE A.T.L.S. PROGRAM: (3)

The ATLS Course is designed to teach physicians life-saving skills and a standardized approach to trauma care in the first "the golden hour" following injury.

The goals of the ATLS Program are to provide physicians with a safe and reliable method in the immediate management of the injured patient and the basic knowledge necessary to assess his condition rapidly and accurately, resuscitate and stabilize the patient on a priority basis, determine if the patient's needs will likely exceed the facility's capabilities, arrange for the patient's interhospital transfer and assure that optimum care is provided in every step of the way.

THE A.T.L.S. CONCEPT: (3)

The "classic" medical approach to trauma was identical to any undiagnosed medical condition - extensive history, physical examination, differential diagnosis, list of ancillary tests, etc, etc. - all of which did not satisfy the needs of the injured patient.

The ATLS program is based on three concepts:

The most important one is to first treat the greatest threat to life. Next, the lack of a definitive

diagnosis should never impede the application of an indicated treatment.

Finally, a detailed history is not a prerequisite to begin evaluating a trauma patient. The result was the development of ABC's approach to evaluation and treatment of the injured.

The ATLS course teaches that life threatening injury kills and maims in a certain reproducible time frame. For example, the loss of an airway kills more quickly than the loss of the ability to breathe. The latter kills more quickly than the loss of circulating blood volume, etc, etc. Thus, the mnemonic ABCDE defines the specific, ordered, prioritized evaluation and interventions that should be followed in all injured patients:

A: Airway with cervical spine control
B: Breathing
C: Circulation
D: Disability or neurologic status
E: Exposure (undress) with temperature control.

<u>OVERVIEW OF THE ATLS PROGRAM</u>: (3)
The ATLS program emphasizes the first hour of Initial Assessment and Management of the injured patient. Starting at the time of injury the concepts of Initial Assessment include:
1) Preparation, 2) Triage, 3) Primary Survey (ABC's), 4) Resuscitation, 5) Secondary Survey (head-to-toe), 6) Continued postresuscitation monitoring and re-evaluation, 7) Definitive care and 8) Transfer.

1) PREPARATION:
For the trauma patient preparation occurs in two different clinical settings. **In the prehospital phase:** the prehospital agency must transfer the injured patient to the closest appropriate hospital. Every effort should be made to minimize scene time.

In-hospital phase: Advanced planning for the arrival of the trauma patient is essential. A suitable area should be kept available for the trauma patient. Proper equipment should be organized and tested. A method to summon extra assistance should be in place.

All personnel who have contact with patients must be protected from communicable diseases (AIDS, hepatitis). Transfer arrangements with trauma centers should be established.

2) TRIAGE:
Triage is the sorting of patients based on the need for treatment and the available resources to provide that treatment.

3) PRIMARY SURVEY:
Is designed to identify all immediate life-threatening injuries within minutes of arrival and treat them as they are discovered.

4) RESUSCITATION:
The management of life threatening problems identified in the primary survey is continued, by protecting and securing the airway, providing vigorous shock management - intravenous lines, and Ringer's lactate. Adequate resuscitation is best assessed by quantitative improvement of physiologic parameters monitoring ventilatory rate, pulse, blood pressure, pulse pressure, arterial blood gases (ABG's), temperature, urinary output,etc.

5) SECONDARY SURVEY:
Is a detailed head to toe evaluation. The secondary survey does not begin until the primary survey (ABC's) is completed, resuscitation is initiated, and the patient's ABC's

are reassessed. The total patient evaluation of the secondary survey includes physical examination of head and skull, maxillofacial, neck, chest, abdomen, perineum, rectum, musculoskeletal and complete neurological examination. Appropriate roentgenograms, laboratory tests and special procedures are perfomed without ommiting to insert "tubes and fingers" in every orifice.

6) RE-EVALUATION: The trauma patient must be re-evaluated constantly to assure that new findings are not overlooked and to discover deterioration in previously noted symptoms.

7) DEFINITIVE CARE:
After identifying the patient's injuries, managing life threatening problems, and obtaining special studies, definitive care begins.

8) TRANSFER:
If the patient's injuries exceed the Institution's immediate treatment capabilities, the process of transferring the patient is initiated as soon as the need is identified. Delay in transferring the patient to a facility with a higher level of care may significantly increase the patient's risk of mortality. Complete immobilzation of the entire patient is required at all times until a spine injury is excluded and especially when a patient is transferred.

EDUCATIONAL FORMAT OF ATLS: (3)
The Student Course is designed to train physicians in the concepts, skills and techniques used in initial patient management. Its unique educational format includes the use of lecture presentations, skill demonstrations, group discussions, practical life saving skills, simulated patient scenarios, and written and practical skill tests. This educational format affords the physician the opportunity to practice life saving techniques under live and simulated conditions. Thus, upon completion, the physicians should feel confident in implementing the trauma skills taught in the ATLS course.

PARTICIPATION IN A.T.L.S. STUDENT COURSES:
The ATLS Course is addressed to:
1) the physicians who infrequently treat trauma patients with an easily remembered method for evaluating and treating the victim of a traumatic event,
2) the physicians who frequently treat trauma patients with a scaffold for evaluation, treatment, education, and quality assurance and provides a system of trauma care that is measurable, reproducible and comprehensive.

Candidates for the course are doctors from varying specialties (8) (Table I). This improves coordination and communication and prevents conflicts as the whole team learns the same language and works along the same protocol (9). As no single physician can attend to all needs of the trauma patient, the team concept is imperative for optimal care delivery. Every effort should be made to build an "esprit de corps" that permeates the entire team and hospital (20). Based on these facts Safar (15) suggests that all members of the trauma team should take ATLS course together.

Since their introduction, ATLS courses have been very popular in Greece. Candidates have to wait many months before getting in a course. Similar experience was seen in other countries. (9).

CONTINUOUS QUALITY IMPROVEMENT OF A.T.L.S.:
The ATLS faculty national and regional are charged with maintaining the high caliber of the ATLS program and ensuring that all

ATLS courses are conducted in accordance with the precepts of ACS-COT.

Presentations of lecture contents and performance of technical skills must adhere to the national standards and minimum criteria of ACS-COT. Practical skills recommend **one** safe and reliable method to perform each technique.

The instructors of the ATLS course are physicians who have successfully completed the student course with a test score above 90%, have effective communicative skills and demonstrate enthusiasm for and positive commitment to ATLS program. The ATLS Instructor Course, pedagogically oriented introduces a new component in medical education ***"teaching how to teach".***

The medical educator of each program, with a doctoral degree in education /pedagogy, teaches adult learning, strategies for lecture, lab and skills, evaluates teaching qualities of candidates and acts as role model for successful teachers and effective communicators.

The last edition of ATLS manual was published in April 1993 and this weekend at the International ATLS Meeting in Chicago, the first meeting for th next 1997 edition will be held.

A.T.L.S. has stood the test of time (>14 years). It has been taught and accepted by well over 150,000 physicians.

A.T.L.S. is reviewed and rewritten every 4 years. There is compulsory recertification of both instructors and students with every manual update.

What other medical training program includes such measures to ensure standards are maintained? (11).

THE INFLUENCE OF A.T.L.S. ON TRAUMA CARE:

It is anticipated that through ATLS a significant reduction in trauma morbidity and mortality will be accomplished. (3). Although the ATLS program has widely spread in the world and more than 150,000 physicians have been trained, its effectiveness has not been conclusively demonstrated (23), except by a first on outcome study by Ali et al (1). These investigators compared mortality and morbidity before and after the introduction of the ATLS course. (Table II).

They demonstrated that the mortality decreased in the post ATLS period as did major and minor disability. It was concluded that the ATLS program had a strongly positive impact on trauma outcome.

In a more recent publication Ali and coworkers (2) concluded that the increased frequency of lifesaving interventions in the post ATLS period may account for the improved post-ATLS trauma patient outcome. Multivariate modeling study showed that the presence of A.L.S. first and trauma center second were the best predictors of decreased per capita county trauma death rates (14). Other studies suggested that ATLS did not reduce morbility and mortality of trauma patients.(22).

More outcome studies are necessary. However, it will be difficult to prove that ATLS improves patient outcome until all physicians who attend to these patients are ATLS trained. (6).
Furthermore today, it is widely accepted that complete trauma care consists of prevention, treatment and rehabilitation; a total system is required (7). As stated by Strauch (17): "At present, the

epidemiologic characteristics of injury, combined with the conviction, backed by steadily growing scientific evidence that optimal care of the injured mandates a **system** that is responsive immediately, at all times, to provide a continuum of care from the time of injury to the time of maximal recovery, have crystallized surgical thinking with the realization that an integrated system, incorporating components of access, prehospital management (Pre-Hospital Trauma Life Support Course), hospital care (ATLS) and rehabilitation, must be the objective." There have been multiple studies verifying as much as 50% reduction in preventable deaths after implementation of regionalized trauma care. (7). Despite the proven efficacy of trauma care systems in reducing death and disability, less than 25% of the U.S.A. is served by such a system. (7, 17).

SUMMARY:

Worldwide, acute trauma care was disorganized, inconsistent and without a standardized training program, until 1980 when the American College of Surgeons introduced the Advanced Trauma Life Support Course (A.T.L.S.). The A.T.L.S. Course is a continuing medical education program teaching life saving skills, a standardized and safe approach for the trauma care in the first "golden hour" following injury.

The expected decrease in morbidity and mortality is reported in recent studies. More outcome studies are necessary. However it will be difficult to prove that A.T.L.S. improves patient outcome until all physicians who attend to these patients are A.T.L.S. trained.

Before I conclude my speech, I would like to show you an original kind of trauma registry used in Greece. Across Greece, on many sideroads you will notice memorials in the form of small shrines or simple icon stands in memory of trauma victims.

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TABLE I:

PHYSICIAN PARTICIPATION IN THE A.T.L.S. COURSE:

Washington State	U.S.A. 1986-89	Patras, Greece	1993-94
General Surgeons	9.7%	6.4%	57.4%
Residents	14.7%	2%	24%
Surgical Specialties	3.1%	14%	29.6%
General Practitioners	35.6%	14.2%	3.7%
Emergency Physicians	30.1%	12.9%	_____
Anesthesiologists / Critical Care	_____	_____	11.1%

Esposito Arch.Surg. 1992 J. Androulakis, 1994

TABLE II: COMPARE MORTALITY & MORBIDITY BEFORE & AFTER THE INTRODUCTION OF THE A.T.L.S. COURSE

	Pre-ATLS (N=413 pt)	Post-ATLS (N=400pt)
Minor Disability	88.3%	22.4%
Major Disability	6.7%	1.9%
Morbidity	76.7%	46.2%
Mortality	19.6%	6.3%

Ali et al, J. Trauma, 1993

Use of Quality Tools To Re-engineer the Aeromedical Evacuation (AE) System

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SUMMARY

The element of change pervades each of our activities; defining change should be accomplished in a logical fashion using definitive tools. A number of quality tools are available to produce rational, well-defined change in a large complex system. One of these methods, the Theory of Constraints (TOC) will be the focus of this paper with regard to designing and implementing change for the United States (U.S.) Department of Defense (DoD) aeromedical evacuation (AE) system. Improvements in the U.S. AE system may provide a systemic benefit to multinational operations.

BACKGROUND

Several contingency operations between 1985 and 1994 have offered the opportunity to employ the global evacuation systems and processes of the United States. The casualty evacuation system involves the regulation (i.e., finding the appropriate destination for the patient) and the subsequent movement of the casualty within and from each echelon to units providing medical care. The individual patient may then be returned to duty in the combat environment or repatriated for follow-on care. The evacuation system involves many transportation subsystems including surface, both land based and sea based, as well as rotary wing and fixed wing aeromedical evacuation. This paper will focus on the fixed wing, common-user service provided globally for U.S. military forces but playing an increasing service role to United Nation forces and other multi-national forces where the U.S. is a partner. This service will be referred to as the aeromedical evacuation system.

The AE system plays a key role in U.S. national strategy. While the contingency planning requirement for medical care has declined since the end of the cold war, AE requirements have not decreased. In fact, rapidly mobile forces and predicted short engagements dictate a decreased forward medical presence with the alternative that theater Commanders will be more dependent on the AE system to link casualties to life-saving medical care. As military operations have assumed a more mobile, responsive posture, AE responsibilities have expanded. Typically, operations involving U.S. forces include an AE presence from the outset, and AE responsibilities remain until all forces are no longer in harm's way.[1]

The United States Department of Defense delegates advocacy for AE to the Air Mobility Command (AMC). As agent of the Commander, AMC, the Command Surgeon is tasked with oversight of all planning, organizing and equipping activities required, to ensure the AE force is capable of executing its' contingency mission and peace-time tasking. Following Operation DESERT SHIELD/STORM, the AMC Surgeon took several innovative steps to resolve challenges that surfaced during the deployment, employment and execution stages. These changes involved redesigning and restructuring the modules used to build both the theater specific AE system and the global overlay or the strategic AE system (i.e., changing the organization construct of the system), redesigning the basic and follow-on education and training programs, and modernizing the equipment and supplies supporting the system to allow mission accomplishment. The world environment continues to demand requirements for further change to increase flexibility, responsiveness and capability.

THE CHANGE PROCESS - AN OVERVIEW

While these actions were constructive and corrected specific deficiencies, systemic issues remained. A more formal process was required to get to core problems and define resolution. One specific method to confront the continuing process of change is a quality tool called systems thinking or the theory of constraints. "The Theory of Constraints - Applied Systems Thinking" was developed by Dr. Eliyahu M. Goldratt and published in his book, "The Goal" in 1984.[2] To provide a detailed look at remaining and continually changing issues, the Command Surgeon contracted with the Theory of Constraints (TOC) Institute[3] to educate staff members on progressive quality techniques and to facilitate the staffs' transition of AE from a "cottage industry" to an industrial based system, a force structured, trained, and equipped to satisfy the contingency requirements and peace-time needs of the twenty-first century. By working through the TOC techniques the work group linked the endless interdependent events comprising the AE system and identified changes necessary to form a seamless system for the future; similar definition has been accomplished in defining and refining the medical regulating processes. The

Paper presented at the Aerospace Medical Panel Symposium on "Recent Issues and Advances in Aeromedical Evacuation (MEDEVAC)" held in Athens, Greece, from 3rd to 7th October 1994.

applicability of the TOC applied systems thinking is universal and offers an alternative to traditional approaches of problem identification and resolution. Using this technique, the AMC Surgeon's staff conducted an end-to-end evaluation of the AE system in January-February 1994. This evaluation included identifying the current and future AE system based on shifting requirements. The group focused on four major areas; machinery, manpower, methods and money as depicted in Figure 1. The group concluded that dramatic changes were required for the AE system to meet DoD's anticipated needs in the 21st Century; the changes will be reviewed in some detail later in this paper.

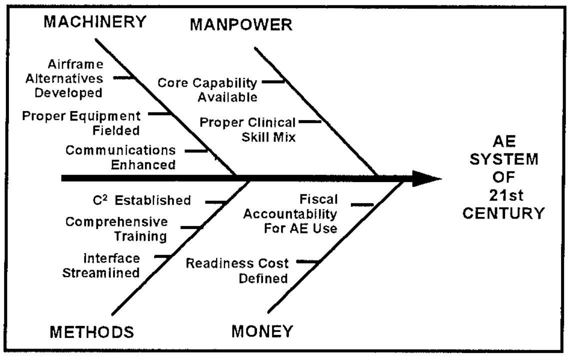

Figure 1
Areas of Improvement

The theory of constraints concept provides a formal process of review to determine shortfalls or challenges to mission accomplishment, hypothesize what would be the most effective new method of providing mission accomplishment and then defining the change mechanisms required to transition to new, more effective methods for a better system.

Those elements of the current way of doing business that are found to be "constraints" are termed "undesirable effects". Each of these need to be critically examined and a "desirable effect" hypothesized for implementation in the future. In the process of identification and formulation of the desirable effect, the process of "transition" is defined; each potential impact to change is reviewed to extract a mechanism to allow for change and obtain a positive outcome for the new way to do business. The change is termed an "injection", an activity that must occur to effect the change required for systemic change. An example of a final view of the process is depicted in Figure 2. Each of the thought processes are critically examined for "sufficient cause" and "necessary condition".

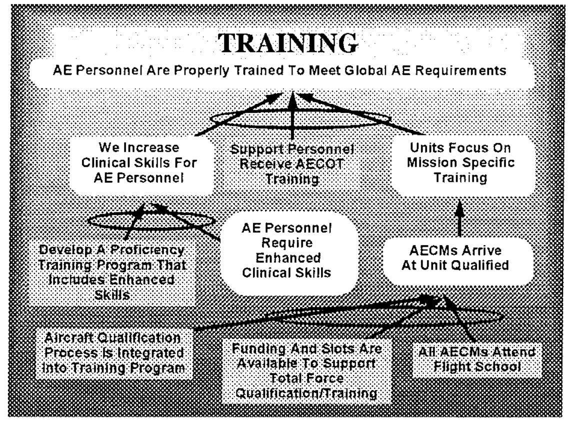

Figure 2
"Future Reality Tree - Training"

THE CHANGE PROCESS - THE ELEMENTS

There are five major elements in the TOC process. (All quoted material is from reference three.)

The first element is entitled the "current reality tree" and involves the definition of "*what* to change". By working through this first step, the group can pinpoint the core problem ("constraint") and the undesirable effects inherent in the current system. Each of these requires some type of change.

The second element is the "conflict diagram". The development of the "future reality tree" or defining "to what to change" involves a bridging process using the "conflict diagram". This technique is "a process that enables a person to precisely present the conflict perpetuating the core problem, and directs the search for a solution through challenging the assumptions underlying the conflict."

The "future reality tree" (third element) then "assumes the existence of the initial injection, relies on cause/effect relationships, and predicts the unavoidable outcomes." "Additional injections are added to ensure the realization of the desired effects, and to block potential negative side effects."

As a fourth element, the "prerequisite tree" provides the bridge between "to what to change" and "how to cause the change". This tree is a process "that enables the dissection of the implementation task into an array of interrelated, well defined, intermediate objectives". This process relies on the "expertise" of the participants to point out obstacles and to meet these obstacles though development of "intermediate objectives".

Once these several elements are achieved, the "transition tree" provides the "how to cause the change". This process is used to

"construct a detailed implementation plan and enables "us to focus on causing a specific change in reality, rather than sticking to a specific action just because we have planned to take it".

THE AE STRATEGIC PLAN

The detailed systematic review resulted in the publication of an AE strategic plan.[1] Thirty-one specific "injections" or areas where improvements are required were specified to initiate and create positive change. As described earlier, the four categories of change involve: machinery; manpower; methods; and money.

For machinery, the injections include:
- Modify the tanker fleet to accommodate aeromedical evacuation use
- Modify the AE ship sets to fit on CRAF (other than B-767)
- Contracting can provide strategic AE airframes
- Patient movement items (PMI) are flight certified
- Logistics support system is available to provide PMI
- Patient/support equipment integrity is maintained
- AE medical equipment is deployable and hardened
- TRAC^{2}ES is fielded
- Portable SATCOM is available for medium/long range communication
- Land Mobile Radios (LMR) provides short range communication
- AE communication is compatible with base infrastructure
- Tri-service communications standards exist

For manpower, the injections include:
- AE capability is structured in small manpower packages for immediate taskings
- Total force integration provides immediate response capability
- AE has acuity staffing tool
- AE has organic capability to complement basic crew mix

For methods, the injections include:
- AE operations structure exists to receive strategic AE mission taskings
- AE Operations Squadron contains capability to respond to immediate taskings
- AEOS collocated with medical centers at designated hubs
- Air Reserve Forces (ARC) AE forces use AEOS as training platform
- All AE members receive standardized training
- Resources are available to support standardized training
- Aircraft qualification process is integrated into standardized training program
- Training includes enhanced clinical skill upgrade
- AE mission support personnel receive contingency training
- Interface module is developed and resourced
- System AE Concept of Operations published

For money, the injections include:
- Funding is shifted to primary user
- Reimbursement process are authorized/improved
- Readiness cost is defined
- Readiness funding is available; business case can be defined

Each of these injections requires formal task definition, coordination and implementation. These actions are ongoing and will continue to promote positive change in the AE system. And as that change occurs, other opportunities for improvement will continue to be realized.

INJECTIONS - CHANGE AGENTS

Several of the injections stated above will be further discussed for additional clarity on the aspect of change required. Several issues are self-explanatory and will not be further addressed.

INJECTION: Modify the AE ship sets to fit on CRAF (other than B-767). The USAF has acquired aeromedical evacuation configuration equipment packages to retrofit B-767 aircraft for dedicated strategic AE service. Due to concerns on the number of B-767 that may be available during any contingency operation, it would be prudent to explore fitting these equipment packages to other long-range aircraft that may be available.

INJECTION: Patient movement items (PMI) are flight certified. PMI includes those items required to move a patient in the AE system, e.g., stretchers, straps, pillows, mattresses, ventilators, etc. Those items that emit an electronic signature need to be tested on the aircraft to ensure they do not interfere with the navigational process.

INJECTION: Logistics support system is available to provide PMI. The logistics support system has available or can acquire sufficient supplies and equipment in the time frame required to ensure it can be moved to the forward facilities as patients are evacuated.

INJECTION: TRAC^{2}ES is fielded. This acronym stands for the TRANSCOM Regulating and Command and Control Evacuation System. It is a globally deployed computer based system to allow medical regulating and intransit visibility of patients throughout the health service support system. The personnel system will be able to access the data base to track individuals for reporting purposes.

INJECTION: Portable SATCOM is available for medium/long range communication. Acquisition of SATCOM communication devises is necessary.

INJECTION: Total force integration provides immediate response capability. A major segment of the AE force structure is in the Air Reserve Component. Careful consideration must be given to the processes used to bring to active duty, reserve and air guard personnel for any required mission.

INJECTION: AE has acuity staffing tool. In conjunction with TRAC^{2}ES, an algorithm must be developed to ensure the appropriately matrixed AE crew and medical attendants are aboard a specific AE mission based on the projected casualty load.

INJECTION: AE operations structure exists to receive strategic AE mission taskings. Contingency operations will require a more robust command and control structure for generating strategic AE; this structure must be built in peacetime and operated as it will perform for contingency mission accomplishment.

INJECTION: All AE members receive standardized training. Currently some AE members receive basic training and follow-on-on training at unit level. This issue posits that all members attend a formal standardized training process as they enter the career field. Additionally, the resource acquisition process must allocate the necessary resources to fund this training initiative.

INJECTION: AE Concept of Operations (CONOPS) is revised and published. Major changes have occurred in the internal structuring of the AE force structure. A revised CONOPS is required to ensure all personnel are aware of the new structure and employment of the force.

INJECTION: Funding issues deal with realigning the AE force structure and mission requirements on a business case methodology with the understanding that contingency requirements dictate a basic training level.

THE GLOBAL IMPACT

The United States Department Of Defense forces are employed on a global basis to support not only declared U.S. national interests but to support the mutually agreed global interests of the United Nations. Additionally, the United States provides military forces in peacetime and contingency operations to meet its commitments in various unilateral and multilateral treaties. Humanitarian assistance requirements are an increasing part of this responsibility.

As a service support element of the overall force structure, the capability provided by the aeromedical evacuation system provides a critical link between the individual combat and/or support person employed forward and the agency providing definitive medical care. As the world continues to shrink and multinational military employment becomes the recognized means of international support, these enhancements will provide an ability to support multinational health service support and repatriation of those personnel who become casualties.

As defined in multinational agreements applicable to specific operations, the United States Department of Defense aeromedical evacuation system plays an integral part of international force support. The ongoing improvement of this capability will allow a continuing improved support as the nations work together to improve global stability.

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The Canadian Experience in UN Airevac
Sarajevo Airlift - April 93-October 94

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SUMMARY

For the first time since the Korean Conflict, Canadian aeromedical evacuation (airevac)crews have been deployed to a theatre of war. While certainly not of the same magnitude as the Korean operation, this deployment has helped us re-learn some of the lessons forgotten in the intervening 40 years, and has reinforced the readiness posture for which we have trained. The vagaries of emergency airlift have brought our airevac mission very clearly into focus.

BACKGROUND

In April 1993, an airevac team of one flight nurse and one flight medical assistant was deployed to the Airlift Coordination Element (ALCE) in Ancona, Italy in support of Canadian ground troops in the former Yugoslavia. Canada had always had immediate European airevac response from nearby CFB Lahr, Germany, but with the withdrawal of all our troops in April 1993, the closest Canadian airevac support was now at 8 Wing Trenton, Ontario, 12 flying hours away. Since a CC130 was already on station in Ancona flying humanitarian supplies into Sarajevo for the United Nations High Commission for Refugees (UNHCR), the addition of these two crew members allowed a flexibility of mission in the case of a disaster to our troops in Bosnia/Croatia.

After four months of carrying wounded Canadian soldiers from Sarajevo/Zagreb to the US Army hospital in Landstule, Germany, our mission changed dramatically. On 22 August 1993 five year old Irma was brought from Sarajevo to Ancona by a Canadian medical crew aboard an RAF 130, beginning the flood of wounded refugees to safe havens all over the world. Our mission changed from the Canadian focus to the UN humanitarian one; our flying went from two missions monthly to upwards of 12. The frequency of flying, and the different quality and quantity of patient required that we re-evaluate our procedures and equipment.

CANADIAN AIREVAC SYSTEM

To understand the successes and difficulties of our deployment, it is first necessary to understand the Canadian airevac environment. Since our military medical system is small, yet the distances between military units are extremely large, airevac is a "centrally administered and de-centrally operated" system. At each of the 13 Air Force Wings across the country there are between 1 and 7 nurses, and 4 and 16 Medical Assistants who work full time in the wing medical clinic. This gives us a total of 51 nurses and 158 Medical Assistants Command-wide. As part of their primary job, they are required to receive airevac training and annual proficiency certification to be prepared to fly an airevac mission at any time.

Paper presented at the Aerospace Medical Panel Symposium on "Recent Issues and Advances in Aeromedical Evacuation (MEDEVAC)" held in Athens, Greece, from 3rd to 7th October 1994.

The Canadian Air Force flies six different airframes capable of airevac (2 international and 4 domestic), with wing medical squadrons logging from one to one hundred missions per year. As a result there is an inherent problem in standardizing the qualification, and maintaining enthusiasm for the mission. To solve these problems we have created an Aeromedical Evacuation Standards Officer (AMESO) at each Air Force wing. Once yearly, this nursing officer is brought to our airevac school at 426 Squadron, Trenton to be certified as a standards officer. The process includes written examinations, equipment checks, and a live-flying mission which includes emergency drills. When the AMESOs leave Trenton they are fully conversant with the two internationally used airframes, the CC130 Hercules and CC144 Challenger, emergency procedures, and the techniques of evaluating their unit members. This very intense week serves not only to update one officer from each unit in the basics of the airevac mission, but it motivates this officer to return to the unit and generate enthusiasm at the unit level. "The secret to success does not lie in power, nor in money - the secret to success lies in enthusiasm."

The AMESO is the pivotal person in our airevac training and standards system. When a mission or deployment is announced, it is the AMESO who recommends crews to do the job, and the AMESO who denies the privilege to those who have not met the standard. In all cases the AMESO's recommendation is central to the standardization and tasking process.

DEPLOYMENT CHALLENGES

COMMAND and CONTROL

The tasking of CF personnel is usually done by the Group Headquarters responsible for the operation; in airevac's case the principal group is Air Transport Group in Trenton, Ontario. However, as is true for all support trades, the Group did not have sufficient integral personnel to maintain a constant aircrew turnover. Therefore, the tasking function reverted to the agency with all the resources at hand, the Command in Winnipeg, Manitoba (1200 miles away). This evolution required constant liaison among the many agencies involved, including plans, operations, airlift, Wings, training and medical supply. Getting the right people to the mission at the right time has been time-intensive, especially as the parameters kept changing. The task fell to the Command Nurse Air Command as the only coordinating agency, and while most things went well, there were some last minute deployments, and early arrivals for airplanes. Fortunately there were no late arrivals. Future deployments will be easier due to the experiences of this first deployment.

OPERATIONS ACCEPTANCE

It was not difficult to establish the requirement for this deployment. The need to support the soldier on the ground in Bosnia was clearly seen, and enthusiastically supported. However, once the command structure had established the medical cell inside the ALCE, it was much more difficult to establish the need for two

crew members in Italy who were required for active flying only sporadically, two or three days a month. Further, the deployed ALCE Commander required a change to his terms of reference (TORs) to enable him to divert his aircraft from UNHCR duty to the purely Canadian mission of an airevac. Command involvement in TORs will occur much earlier in the process in future.

Understanding leads to acceptance. Once the ALCE Commander became accustomed to the airevac role, he was intent on keeping his medical crew nearby. When a crew was obliged to bring a patient all the way back to Canada, the ALCE Commander immediately agitated for the return of "his nurse". When a second ALCE was established in Nairobi under emergency conditions, the medical crew was an integral part of the response from the outset.

TERMS OF REFERENCE

When first tasked, the stated mission for our medical crews was tenuous at best. Without references for the deployment of airevac crews, the first nurse to join the ALCE was not well versed in her role, and not understood by the ALCE staff who had never had to consider the medical crew as part of the team before. She was quite literally required to write the medical terms of reference, which were then modified at will by her successors. While this was part of the initial challenge of the job, it also created unnecessary uncertainty and stress as each team was required to explain the "do's and don't's" of their job to aircrew who were unfamiliar with the continual deployment of medical crew. It was a learning experience for all concerned, and not until crews began to rotate through for a second tour did the medical crew truly become a part of the team.

The first four months, when the mission was simply to provide airevac support to the ground troops in Bosnia/Croatia, were quite sedentary - only two missions a month were flown to the European destination of Landstule US Army Medical Centre in Ramstein Germany. However, when the team began flying wounded refugees and their families out of the theatre of war, the terms of reference changed again.

An understanding of our role was now required from all agencies, including not only our own aircrews but the UNHCR in Geneva and Ancona, the Red Cross in Sarajevo and Italy, and the medical facilities on the ground in Sarajevo. The medical crew was required to respond to the imperatives of airevac in a war zone, under fire or in imminent danger. While tactical principles are taught on the initial airevac course, this was the very first time that these concepts had been implemented, requiring decisions on such basic concepts as getting off the aircraft to take report on patients in a quieter environment - if you did, you were quite likely to be left behind, since the aircraft commander, in the interest of his aircraft's safety, was intent on a 5-8 minute turnaround time.

Other changes occurred as well. The strictly airevac role of the medical personnel was immediately expanded to include doing sick call for the four nations of aircrew stationed at Ancona. Liaison with the local medical establishment was critical to this expanded role. Further, Critical Incident Stress reactions were not uncommon during the first few months of the mission, and it became the nurse's responsibility to give a pre-deployment briefing to all personnel prior to leaving

Canada, and to have returning personnel fill out a response form upon return to Canada. In between, as the mental health officer, she occasionally de-fused a critical situation.

Of particular note, some medical crews required de-briefing themselves, and understandably so considering the injuries and hopelessness which they confronted every day. This old lesson was not forgotten - medical staff need help too.

All these varied functions outdated the four-month-old TOR's, but helped the medical crew be truly incorporated into the ALCE as full members of the UNHCR mission. A team had been forged.

And a team was very much required. The third crew to be deployed took the nurse and medical assistant from different Air Force Wings in Canada. While the mission was successfully accomplished, the team recommended if at all possible that the medical crew members should be tasked from the same home unit. Once in theatre, the two members of this team require complete trust in each other's capabilities. This can be best achieved if they have trained and worked together at their home unit, limiting the adjustment factor to that of the working environment. Once again old lessons were re-learned, and since then crews have been tasked from the same airevac units.

TRAINING READINESS

Pre-deployment training was the first of our challenges in choosing crew for the Ancona ALCE. Initially personnel were chosen from units whose primary mission was CC130 Hercules airevac. This allowed a high confidence level in sending crews into an unknown theatre since, though the mission was undetermined, the familiarity with the aircraft would eliminate one obstacle. Experienced airevac crews are imbued with a very large measure of flexibility and ingenuity, and this was severely tested in the first six months of the mission.

This selection method worked very well, until for a variety of imperatives, the three CC130 home units proved unable to continue to provide crews on a continually rotating basis. At that point the other Wing AMESOs were asked to recommend their most knowledgeable and flexible crew members, whose lack of current CC130 knowledge would be secondary to their personal attributes of being able to think on their feet and to expect the unexpected. Again this was a successful strategy.

By this time it was twelve months into the process and the mission was becoming familiar. Less experienced crews could be chosen. At all times a balance of confidence level was attempted between the nurse and medical assistant, with final competency checks given through a quick pre-departure review of their skills by the AMESO at the staging Wing, 8 Wg Trenton.

This tasking strategy worked only because small numbers of crew members were required at any time; only three crews were on standby at a time for deployment, giving everyone the opportunity to brush up on their airevac knowledge and CC130 familiarity. Should large numbers of crews be required simultaneously, our raining process would need a further personnel refresher week at 8 Wg prior to deployment. The standard of aircraft-specific training at every airevac-tasked

medical squadron is very difficult to maintain at an operational level.

EQUIPMENT AND SUPPLIES

Though organizing the personnel deployment was a learning experience, the logistics of providing the right equipment in the right place at the right time was a distinct challenge. Since each airevac crew flies intermittently within Canada, approved airevac equipment is cached at each unit. Theoretically, it was better to keep the equipment in the unit where it could be used and maintained, rather than having it stored in a medical equipment depot where it was less easily accessible. This proved to be a significant problem.

The units were not inclined to release their airevac equipment to a deployment. Crew members tasked to take their equipment overseas with them immediately voiced concern over how their unit would manage domestic airevac in the interim - even if they had not flown a mission in the past six months! And the issue of accountability for very expensive kit became a significant issue which still is not completely resolved.

As this particular obstacle had not been anticipated, this was a "show-stopper". The solution came more by good luck than good management. The airevac equipment which had been positioned in Lahr, Germany, though all boxed up and ready to be shipped home, was uncrated and signed for by the first nurse to deploy to Ancona. To my knowledge that equipment has not been damaged or lost, despite all the dire predictions of the account holders. The equipment which is currently in use will be stored in the Central Medical Equipment Depot (CMED) upon its return to Canada and assigned specifically to deployed operations so that the next deployment will be equipped more smoothly.

The re-supply planning was not difficult once monthly flights began into the ALCE. The CMED received the ALCE requirements either by FAX or by phone, and the materiel was on the return flight. Urgently required items were couriered to the unit or purchased locally.

This plan failed to work in only one major facet - that of oxygen supply. The airevac teams took with them a Flynn resuscitator, which delivers emergency oxygen for up to 25 minutes from a small E-sized tank. Though the flight from Sarajevo to Ancona takes only 58 minutes, this Flynn was often used and therefore the crew needed a reliable supplier of medical oxygen.

Though there were suppliers available, as recommended by the Italian Red Cross and local hospitals, they were unable to fill our tanks due to regulator size incompatibility. After a futile search for a compatible source, the crews resigned themselves to sending tanks back to Canada for refill and return on rotation flights. This was a very cumbersome procedure, resulting in delays in the replacement of this essential item. Necessity is the mother of invention, however, and before long a jury-rigged adaptor provided the solution, with the two incompatible regulators fixed to either end of a piece of high-pressure hose. With ingenuity, the largest problem of the early deployment was solved.

LESSONS LEARNED

This mission has provided a unique test to

our operational airevac plans, and the opportunity for longterm benefit at a very small cost in personnel and equipment. Not all the problems were anticipated - others should have been.

In command and control, certainly we have re-learned the concepts of crew solidarity which are always apparent to squadrons and army regiments. The lines of tasking responsibility have been clarified, and terms of reference have been established.

We were very pleased to see that our years of airevac training had been well worth while. For a nation which had not deployed airevac resources in 40 years, we were prepared and eager to fill this mission, and indeed medical crew members are still calling to volunteer for deployment. But the need for crew member flexibility, resourcefulness and CC130 readiness has been firmly fixed in our training lexicon, so that next time will be no different.

Equipment must be ready at all times to deploy from a medical depot, without dependence on the individual airevac units. Despite the added cost of this option, quick deployment with the correct aircraft-compatible equipment may depend on this caching of materiel. We have learned that a stand-alone mission is not effective especially with regards to oxygen supply, and can now foresee the problems of re-supply.

CONCLUSION

The deployment of Canadian airevac crews to the ALCE Ancona has been a success in every aspect. Crews have received experience in tactical airevac, occasionally under fire, and have cared for war injuries in the air environment. That experience is invaluable in the preparation of forces for conflict after decades of peace. And significant problems can be addressed now, instead of during the confusion of mass deployment.

Canadian airevac crews have earned the respect and thanks of the international community for their ingenuity, professionalism and dedication. In backing into a UN humanitarian mission which was not the original focus of the tasking, Canadian flight nurses and flight medical assistants have been deployed for 18 months in the most valuable and challenging mission of their careers. To date 102 missions have been flown, bringing 733 wounded refugees and 722 family members to the safety of the West. Experience, after all, is the best teacher.

UNITED NATIONS AEROMEDICAL EVACUATION OPERATIONS IN THE FORMER YUGOSLAVIA

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SUMMARY

This paper examines intratheater aeromedical evacuation of United Nations Protection Force (UNPROFOR) casualties during peacekeeping operations in the republics of Croatia, Bosnia-Hercegovina, and the Former Yugoslav Republic of Macedonia. Its purpose is to inform NATO countries that participate in future UN operations of the inherent deficiencies of the force medical support for such multinational missions. UNPROFOR consists of over 40,000 personnel representing 36 nations organized into at least 37 battalion size units in a widely dispersed deployment. The paper is a summary of observations from the HQ, UNPROFOR Medical Branch compiled from reports, liaison visits to units, and direct participation in planning and training activities for aeromedical evacuation. Effective aeromedical evacuation in this mission was complicated by many factors: lack of dedicated aeromedical evacuation units; difficult weather and terrain; restrictions of flight imposed by warring factions; lack of standardized communications and medical equipment; wide variation in the level of proficiency, training, and experience of various contingents; and lack of standardized international procedures and policies. There is no medical unit in theater to bridge the gap between first level medical units in the field and the level three field hospitals. Accordingly, most NATO member contingents have elected to place field surgical teams at the battalion level. Discussion includes capabilities provided by military and civilian utility helicopter and fixed-wing aircraft. Efforts in training and simplification of procedures for evacuation are also summarized. The limitations of the current system are described, and existing shortfalls are defined with recommendations for future improvements.

PREFACE

The authors of this paper served consecutive tours as the Assistant Force Medical Officer assigned to Headquarters, UNPROFOR Medical Branch. Both authors were assigned to UNPROFOR for six months of temporary duty and serve as active USAF residency trained practitioners of aerospace medicine. The paper is based on experiences with intratheater aeromedical evacuation in the entire theater for the period October 1993 through September 1994. The authors performed medical planning, training, and liaison functions for the UN force. The purpose of the paper is to inform NATO nations of the character of UN medical operations and does not reflect policy of the United Nations or United States Air Force.

1. BACKGROUND

1.1 The Conflict

Following almost a year of mounting internal disorder and a previous attempt to secede from Yugoslavia, Croatia declared its independence from Yugoslavia in June 1991. Ethnic Serbs in Croatia felt threatened, and federalist Serbia resisted the secession. A war followed between the Croatians and the Serbs in which the UN intervened. Four UN Protected Areas (UNPAs) were established in Croatia in June 1991 to halt fighting between Croatians and Serbs. Approximately one third of Croatia is controlled by indigenous Serbs who have declared their own independent Republic of Serbian Krajina (RSK) which is closely aligned with Serbia. A tense cease-fire exists along the conflict line between the Croatian Army and the Army of the RSK with frequent cease-fire violations.

War began in Bosnia in March 1992 as Bosnian Serbs feared for their positions and began ethnic cleansing in rural areas. The Bosnian Serb Army with heavy support from Serbia

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concentrated on establishing and maintaining corridors connecting them with Serbia and Krajina and seeking an outlet to the Adriatic. The Bosnians and Muslims fought to maintain control of their territory and various ethnic enclaves surrounded by Serbs. Bosnian Croats with help from Croatia sought to maintain control of their enclaves and thwart Serbian access to the Adriatic. Fighting was widespread by the winter of 1992/1993. Although the Bosnian Muslims and the Bosnian Croats were generally allied against the Serbs, they sometimes came into conflict with each other. A rebel Muslim faction led by Mr. Abdic is fighting the Bosnian government forces in the Bihac region with the support of the armies of the Bosnian Serbs and the RSK. Efforts to reach a mutual political settlement in Bosnia-Hercegovina have failed and the conflict continues as each side initiates or reacts to offensives designed to secure additional territory or supply routes. There has been a serious breakdown of the normal services throughout the conflict area with a severe impact on hospitals, clinics, pharmacies, public utilities, public transportation and other basic civil infrastructure.

1.2 UN Intervention

UN Security Council Resolution 743 on 21 February 1992 established the United Nations Protection Force (UNPROFOR) with the mission of peacekeeping in Croatia and Bosnia-Hercegovina. UN Security Council Resolution 770 on 13 August 1992 gave UNPROFOR the mission to take all necessary measures to facilitate the delivery of humanitarian aid to Bosnia-Hercegovina under the coordination of the UN High Commission for Refugees (UNHCR). UN Security Council Resolution 795 on 11 December established FYROM command as a preventive UNPROFOR deployment to prevent hostilities along the Former Yugoslav Republic of Macedonia (FYROM) border with Serbia. UNPROFOR Headquarters is located in Zagreb, Croatia. It controls UNPROFOR operations in the UNPAs as well as overseeing operations of the subordinate commands. HQ, BH Command directs all UNPROFOR operations in Bosnia-Hercegovina.

1.3 UNPROFOR Disposition

UNPROFOR strength numbers over 40,000 personnel from 36 nations in a widely dispersed deployment. UN soldiers man checkpoints, observation posts, and perform patrols to monitor cease-fires along the conflict lines. They are also involved in mine clearance, engineering projects, convoy escort, airfield management and supply route reconnaissance to ensure the safe delivery of humanitarian aid. There are approximately 37 battalion size units ranging in size from 400 to 1500 soldiers. Each battalion has an area of responsibility and is generally deployed in company size garrisons.

Each battalion has its own battalion medical support with a battalion aid station, company aid posts, and ambulances. Battalions have between one and nine physicians assigned. Some Battalions have a dental officer. Some contingents have physicians at the company level while others have them at the battalion HQ with only medical technicians at the company level. There is a tremendous variation in medical training, equipment, and personnel among the contingents.

Seventeen units have augmented their battalion level medical assets with field surgical teams (FSTs). These are national assets designed to support their own contingents; but in practice, they provide emergency surgery coverage for all UN units in their sector. Most of the FSTs have a single operating table and one surgical team. Typical staff size is 12 personnel. They have minimal lab and radiology capability. Some are equipped for blood storage. They are designed for lifesaving surgery and can hold small numbers of casualties for short periods until further evacuation can be arranged. The French Medical Group surgical team in Sarajevo consists of two surgical teams.

Several battalions are assigned to a sector, the UN equivalent of a brigade; however, there are no sector level medical assets. Prior to September 1993, a medical battalion was stationed in Croatia. It had a company in each sector with a headquarters company in Zagreb. This organization greatly facilitated a coordinated medical network in the UNPAs. It provided consistency of communications, evacuation, medical reporting, and medical training in each sector. Local civilian medical facilities in the conflict area are generally unsuitable for use by UNPROFOR personnel.

1.4 Field Hospitals

Two field hospitals provide third echelon medical care for UNPROFOR. The US Field Hospital in Zagreb has primary level three coverage for Croatia and secondary coverage for FYROM Command and BH Command. The US Hospital also provides basic medical and dental care to all UN personnel in the Zagreb area as well as accepting outpatient referrals from the UNPAs. The hospital is staffed by approximately 140 personnel on a rotational basis from the United States Army, Air Force, and Navy. Medical specialties include general surgery, orthopedic surgery, oral surgery, anesthesia, internal medicine, family practice, psychiatry, and general dentistry The hospital is housed in TEMPER tents and ISO containers and is partially sheltered inside an aircraft hanger. The hospital site is adjacent to the UNPROFOR Air Operations parking ramp for both fixed-wing and helicopter aircraft. It has a 4 bed intensive care unit, a medical/ surgery ward, and a minimal care ward totaling a 60 bed capacity. It has two operating rooms with four operating tables. Other services include a medical laboratory and blood bank, radiology unit with portable fluoroscopy capability, and physical therapy department. The Norwegian Medical Company (NORMEDCOY) 60 Bed Field Hospital in Tuzla has primary level three coverage for BH Command. Its capabilities are almost identical to the US Hospital. NORMEDCOY consists of two units: the Norwegian Hospital, and the Norwegian Evacuation Platoon which is equipped with 8 armored ambulances. It is located on the same compound as the

Norwegian Helicopter Squadron. It is approximately 20 kilometers from the UN-operated Tuzla Airfield.

1.5 Medical Command and Control

Medical Command and control is limited to the HQ, UNPROFOR Force Medical Branch and HQ, BH Command G3MED. The Force Medical Branch has 6 officers (2 physicians, a public health officer, a medical operations/plans officer, an air evacuation operations/plans officer, and a medical logistics officer) and 2 NCO clerks. The position for an air evacuation operations/plans officer was not filled until August 1994. BH Command has a chief medical officer, a medical operations/plans officer, and an enlisted clerk. The Sector Headquarters each have a Sector Medical Liaison Officer. This is a senior medical officer appointed from one of the contingent medical units in the sector. His role is to advise the sector commander on medical matters and to assist the Force Medical Branch in communication with units and implementation of force medical policies. Since this is an additional duty position, the role is one of medical planning and cannot be relied upon for supervision of sector medical operations. The French, United Kingdom, and Canadian contingents have medical elements assigned to their contingent headquarters. These personnel are important points of contact outside of the UN chain of command for medical planning. Control of all air assets assigned to UNPROFOR is the responsibility of UNPROFOR Air Operations which has staff assigned to each major headquarters and every sector headquarters. The Medical Branch does not control any intertheater air evacuation assets. Those assets are contingent nation responsibility.

1.6 UNPROFOR Casualties

Casualties among the UN troops from June 1991 to 15 July 1994 amount to 474 battle injuries and 46 battle deaths. There have been an additional 594 major non-battle injuries and 53 non-battle deaths. Casualties have been divided almost equally between Croatia and Bosnia-Hercegovina. FYROM Command has not had any battle casualties. Over 1100 soldiers have been repatriated for medical reasons.

1.7 Casualty evacuation

Casualties in the UNPAs are evacuated by ground to a battalion aid station and/or field surgical team. Then they are evacuated by helicopter or ground ambulance to the US Hospital in Zagreb. Level 4 care is available from Croatian medical centers in Zagreb, if needed. The US Hospital serves as an aeromedical staging facility to repatriate casualties to their home countries. Serious casualties from accidents in FYROM are evacuated by helicopter to the Military Hospital in Skopje. From there, they can be transferred by fixed wing UN transport to the US Hospital, or they can be directly repatriated to their home country. Casualties in BH Command are normally transferred by ground to a field surgical team. From there, they are evacuated by helicopter to either the Norwegian Hospital or to Split. At the Split airport they are either transferred directly to an intertheater air evacuation aircraft for direct repatriation, or transferred by UN fixed-wing transport to The US Hospital. Patients requiring repatriation from the Norwegian Hospital are transferred to Zagreb or Split by either helicopter or fixed-wing aircraft. There is no inpatient aeromedical staging facility at Split. The French Air Force provided one on a temporary basis during initial enforcement of the heavy weapons exclusion zone around Sarajevo. Had the airport at Sarajevo become closed for a prolonged period, the main route of casualty flow from Sarajevo would have been by ground ambulance to a safe helicopter staging area and then to Split. An inpatient staging facility was needed for this contingency to facilitate transfer to the US Hospital or repatriation. The aeromedical staging facility was not used and was withdrawn following the crisis. Currently, French, British, and Spanish clinic teams at Divulje Barracks provide transport and manpower for transfer of casualties at Split. Their dispensaries can be used for holding of six to ten stable patients. A direct aircraft to aircraft transfer at Split Airport is used for urgent cases. Less urgent cases are unloaded at Divulje Base and transferred to Split Airport by ambulance. Humanitarian medical evacuation of refugees in support of UNHCR is periodically conducted using BH Command air assets. These evacuations are staged through the Split airport where the patients are transferred to UNHCR sponsored aircraft for movement usually to Ancona, Italy. Other UNHCR refugee flights have been staged from Llubljana, Slovenia.

2. PROBLEMS

2.1 Ground evacuation

Ground evacuation is difficult, often impractical, and sometimes impossible in this theater because of numerous factors. The force is widely dispersed. Units are thinly spread over large areas, often isolated by geographic barriers and warring faction troops from their main garrisons. The mountainous terrain that predominates in much of the region imposes severe restrictions to rapid movement. Rivers and marshes in the plains, coupled with the destruction of numerous bridges create further natural barriers. Most of the roads in the conflict area are limited to small, winding, poorly marked secondary roads that have seen heavy use and little maintenance during the past three years. Some main supply routes in Bosnia-Hercegovina are nothing more than single lane dirt roads. Heavy accumulations of ice and snow make many routes impassable in the winter. Dense fog creates a further safety hazard. Casualty evacuation is impeded by numerous warring faction checkpoints, particularly when a conflict line must be crossed during the evacuation. Some routes are closed unpredictably by hostilities or by the whim of the controlling party. The presence of numerous unmarked minefields is a further concern. There are no level 2 medical units available to carry out the mission of ground evacuation and sustaining treatment since the withdrawal of the British Medical Battalion from the UNPAs in September 1993. Battalion medical units must be able to evacuate casualties to the hospitals with their own assets unless they can be evacuated by

air. This involves sending their ambulances out of their area of responsibility and usually out of radio range..

2.2 Lack of Dedicated MEDEVAC Units

There are no dedicated aeromedical evacuation units in UNPROFOR. Medical Evacuation (MEDEVAC) relies on the use of military and civilian utility helicopters. These aircraft have numerous missions, but their highest priority mission is MEDEVAC. BH Command is best equipped since it has three well-trained military utility helicopter units. These units have trained medical personnel attached and medical equipment available to convert their aircraft into air ambulances. The aircraft are equipped to military specifications with armor, countermeasures and night vision devices to increase survivability in a combat zone. They have no red cross markings to distinguish themselves as MEDEVAC aircraft. Crews are kept on standby in case of an urgent request for MEDEVAC.

The French Helicopter Squadron (DETALAT), based at Divulje Barracks in Croatia supports BH Command with six AS 330 Pumas. The Puma has a maximum capacity of 6 litters and 10 ambulatory casualties. In this configuration there are fore and aft banks of 3 litters each with the top litter patients being inaccessible. Two of the Pumas are equipped with air evacuation equipment sets that have a single self contained litter treatment station and one litter in reserve for transport. The air evacuation equipment station includes a mechanical ventilator, pulse oximeter, ECG monitor/defibrillator, portable suction, oxygen, medical kit with resuscitation equipment, and emergency drugs. The DETALAT Medical Detachment provides two medical teams for the Pumas each consisting of one flight surgeon and one nurse. The DETALAT also operates 4 Gazelle light helicopters which can carry 1 litter patient with very poor access in flight. These have not been used for MEDEVAC missions.

The United Kingdom's Royal Navy 845 Squadron is also based at Divulje Barracks in support of BH Command with 4 Sea King transport helicopters. Maximum capacity is 4 floor-loaded litters, and 8 ambulatory casualties. A more practical capacity of 3 litters allows patient access. Medical equipment includes a portable pneumatic ventilator, pulse oximeter, manual suction unit, oxygen, medical kit, and emergency drugs. An RAF flight medic crews each MEDEVAC flight. An RAF Flight surgeon and 2 flight nurse assistants are available from the clinic if needed.

The Norwegian Helicopter Squadron (NORHELISQDN) operates four Bell 412s form a base in Tuzla co-located with the Norwegian Hospital. Their capacity is 3 litters and four ambulatory casualties. The Norwegian Medical Company Evacuation Platoon provides medical crews (physicians, nurses, and medical technicians) and equipment for all MEDEVAC sorties flown by NORHELISQDN.

The UNPAs in Croatia must rely exclusively on civilian contract aircraft operated by UNPROFOR Air Operations for MEDEVAC. Medical crews have to be borrowed from the US Hospital in Zagreb. The US Hospital provides an on-call team of one physician, one nurse and one medical technician. During the USAF rotation, some of the on-call personnel included flight surgeons and flight nurses, but otherwise they are not specifically trained for MEDEVAC missions. When the mission does not originate from Zagreb, medical attendants have to be provided from the referring battalion's medical staff. These personnel likely have no MEDEVAC training or experience. No medical equipment is prepositioned on the contract aircraft except for litters. The US Hospital maintains one MEDEVAC equipment set for its standby crew consisting of a medical kit with resuscitation equipment and emergency drugs, ECG monitor/defibrillator, pulse oximeter, oxygen, and suction machine. Additional equipment can be sent on request. Electrical equipment is limited to the battery life because none of the aircraft are equipped with compatible power sources. Few of the helicopters are all-weather capable. None of the aircraft are modified for combat operations by the addition of armor, self sealing fuel tanks, or countermeasures. The aircraft carry no red cross markings. UNPROFOR is unable to preposition these aircraft preconfigured with medical equipment and crews because they are used for daily resupply and shuttle missions. Although MEDEVAC is their highest priority mission, aircraft frequently have to be recalled or diverted from another mission before performing a MEDEVAC mission.

Helicopter MEDEVAC support in Croatia relies on 5 contract helicopters based in Zagreb. The Bell 212 has a capacity of 11 passengers or 3 litters and 4 ambulatory patients with medical attendants. Two Bell 206 Long Rangers can carry 2 litter patients each with removal of the co-pilot's seat Specially designed litters are required and access to the casualties in flight is limited. Two Sikorsky S-61Ns can carry 20 passengers or 5 litters and 4 ambulatory patients with medical attendants. The S-61 does not have litter mounts.

Helicopter MEDEVAC support in FYROM Command relies on a mixture of military and contract helicopters. Three UH-60 Blackhawks are operated by the US Contingent. Contract resources include 2 Bell 212s and a Bell 206. Medical crews come from US and Nordic Battalion medical staffs.

Fixed-wing intratheater air evacuation relies on contract transport aircraft based in Zagreb. None of these aircraft are modified for air evacuation. They have a limited number of usable airfields: Zagreb, Sarajevo, Skopje, Tuzla, Split, and Klisa. A Yak-40 is the mainstay for UN fixed-wing air evacuation missions. This medium rough-field capable jet transport is capable of carrying 28 passengers or 5 litter patients with seats removed. It is not possible to use the rear boarding stairs for litter patients. The high cargo door is the only avenue

for loading litter casualties. A second Yak-40 is available, but it is not equipped with a cargo door. An Antonov-26 turboprop transport carries 39 passengers on center-facing seats. 8 floor-loaded litters and 19 ambulatory casualties can be carried by folding up one row of seats. A rear cargo ramp facilitates loading. Two IL-76 jet transports are used for cargo and passenger transport. They can carry 79 seated passengers or 20 floor-loaded litters and 35 ambulatory casualties. The rear cargo ramp facilitates loading.

Intertheater air evacuation is performed by contingent aircraft or commercial air carriers. Contingent owned aircraft consist of dedicated air evacuation aircraft or opportune logistics and troop transports augmented with medical equipment and crews. Repatriation to countries not operating such aircraft is conducted using commercial airlines. A commercial Swiss air ambulance is available to the UN with approval by the UN Medical Director for special cases. France, Great Britain, Spain, Canada, and USA are among countries that have the capability to send aircraft on an urgent basis to evacuate casualties from theater.

2.3 Air Movement Restrictions

Air movement restrictions adversely affect the timeliness and safety of MEDEVAC missions. Overflight of conflict areas *is* limited to strict air corridors and a defined schedule established by negotiation. Variations are allowed only by special clearance.

Deviation of more than a few kilometers or a few minutes can result in the warring parties firing on UN aircraft. Despite adherence to air corridors, many of the UN aircraft have sustained minor battle damage from ground fire. Helicopter landing sites are limited to designated helipads at established camps. Most of these are poorly marked and not lighted.

2.4 Weather

Poor weather and lack of all-weather flying instrumentation and air traffic control systems affect the ability to complete MEDEVAC missions. There are no navigational aids in the conflict area. Aircraft rely on LORAN and global positioning system for navigation and have to perform visual approaches. Low ceilings and fog combined with mountainous terrain create a hazardous flying environment and preclude flying in some areas.

2.5 Operational Factors

Numerous operational factors impact the effectiveness of MEDEVAC in UNPROFOR.

Request procedures: Request procedures for an emergency MEDEVAC mission are complicated. The request is relayed by medical personnel through their battalion HQ and then through the Sector HQ to either UNPROFOR Air Operations or BH Command Air Operations. The flying unit is tasked by Air Operations and a clearance initiated with the warring factions. Clearances have to be approved for each party that will be overflown. The clearance process can take from one to three hours.

Communications: There is no capability for direct communications between MEDEVAC aircraft and ground medical units. Because of limited radio networks, all communications must go through the battalion to the Sector Air Liaison Officer.

Forward basing: There is no forward maintenance capability for helicopters. Contracts do not provide for forward basing of contract crews. Prepositioning of helicopters is limited to daytime only and does not include medical crews.

Fiscal concerns: Fiscal limitations beyond the control of the UNPROFOR Force Commander limit the availability and prepositioning of dedicated helicopters for MEDEVAC. Military helicopters in BH Command are limited to 25 flight hours each per month. This effectively precludes their use for training exercises. Contracts do not have provisions for the additional costs of maintenance and billeting associated with forward basing. Addition of more and better equipped contract helicopters is difficult to achieve under the current limitations.

Language: Language barriers tend to complicate the request procedure for MEDEVAC sorties. Although English is the official UNPROFOR language, not all medical contingents have personnel who can speak English fluently. Nonmedical interpreters have to be used by some battalions to translate and forward requests. Many of the staff officers forwarding and receiving requests speak English as a second language. This sometimes results in delays and incomplete information being received.

Training: The level of training varies widely among the contingents. Some medical contingents have no experience with helicopter MEDEVAC. Training has to be conducted with all contingents on UNPROFOR procedures. Some contingents who have not sustained casualties lack a sense of urgency to prepare for the worst case. Helicopter ground safety is a special concern. There has sometimes been a reluctance by Air Operations to dedicate their limited flight hours to MEDEVAC training exercises with field units.

Sustained operations: The UNPROFOR MEDEVAC system functions adequately for small numbers of casualties, but it remains untested by a true mass casualty scenario. The level of medical manpower and equipment is probably the limiting factor. There are not enough medical crews to fully man the existing aircraft without stripping battalion aid stations, field surgical teams, and the hospitals of manpower and equipment. Response to multiple incidents simultaneously or a sustained mass casualty scenario might overwhelm the medical resources of UNPROFOR.

3. PROGRESS

3.1 Standard Operating Procedures

Published guidance in the form of UNPROFOR Medical Standard Operating Procedures (SOPs) is distributed to all medical units. The SOPs were coordinated with the Air Operations Branch to streamline the MEDEVAC request process. Medical guidance on preparation of casualties for movement by air is included. Responsibilities, capabilities, and safety procedures are described.

3.2 Training

Field training exercises conducted in the UNPAs provide hands-on training with request procedures, configuration, and loading of aircraft. Due to the constant rotation of units, this training is an ongoing effort coordinated by Sector Medical Liaison Officers.

3.3 Experience

Invaluable experience was gained during the successful evacuation of over 277 UN personnel. Additionally, UNPROFOR has safely evacuated over 768 civilian humanitarian medical cases in cooperation with UNHCR

3.4 Freedom of Flights

A recent easing of restrictions on air corridors seems promising. DETALAT, 845 Squadron, and the Norwegian Squadron fly freely in BH Command; however, the Norwegian Squadron uses corridors to reach protected enclaves. Corridors are still in effect in the UNPAs. It is too soon to tell if this is a long term trend or a temporary gain. Overflight restrictions are directly linked to the restrictions the UN and NATO impose on the warring parties' use of airlift. In the past, there was a strict insistence on prior approval and inspection of all warring faction MEDEVAC flights in the no-fly zone. Unofficially, numerous helicopter sorties by the warring factions have been ignored by NATO and the UN as long as they are not involved in air to ground weapons employment. This unofficial *quid pro quo* policy seems to be fruitful.

3.5 Field Surgical Teams

Field surgical teams provide improved forward trauma care at 17 locations. Although these are contingent assets, they readily provide care to all UNPROFOR personnel. In March 1994 the Medical Branch was successful in placing its first sector level FST. This team from the Czech Republic was placed under the control of the sector commander at a location of his choosing specifically to provide surgical support for his entire sector. The FSTs have been instrumental in saving lives. They compensate for the deficiencies in land and air evacuation. They buy time to arrange MEDEVAC, but they do not replace the need for MEDEVAC. They reduce the evacuation of unstable casualties.

3.6 Medical Battalion

Indonesia has agreed to contribute a medical battalion to cover the UNPAs. Coordination is underway with the Force Medical Branch to ensure that the unit arrives with the proper equipment, personnel and training to perform its mission successfully.

4. CONCLUSIONS AND RECOMMENDATIONS

Continued reliance on improvised techniques of MEDEVAC is likely to cost UN peacekeeper lives. Rapid and responsive MEDEVAC capability should be the medical standard and not the exception. Progress has been made in developing a MEDEVAC system, but serious deficiencies exist, particularly in the UNPAs.

4.1 Seek a Dedicated MEDEVAC Unit

The UN needs to continue to aggressively seek donors of dedicated MEDEVAC units from contributing nations. A lead country should be identified that can and will coordinate and execute the air evacuation mission with integrated assets. This includes equipped aircraft capable of operating in a hostile environment, dedicated and trained medical crews, aeromedical staging capability, and a command and control network. If no contributing nation is found, expand contracts to obtain additional capable resources.

4.2 Preposition MEDEVAC Assets

Prepositioning of dedicated MEDEVAC assets, especially in the UNPAs, would greatly improve responsiveness. Evacuation time will be greatly reduced. Local training of medical units will be enhanced. Some refueling stops will be eliminated. Prepositioning allows helicopters to take off from the field with casualties in weather too marginal to land, then execute an instrument approach into the airfield at Zagreb.

4.3 Standardize Communications

A Standardized theater-wide medical radio network is needed to allow better coordination of medical units. All medical units need the capability to communicate directly with MEDEVAC helicopters. As a minimum, each battalion should have at least one radio capable of reaching the other units in its sector and all MEDEVAC aircraft. All MEDEVAC aircraft should have a radio capable of communicating with the medical units they are supporting.

4.4 Planning

Continued close coordination between the Medical Branch and Air Operations is essential to ensure that future plans and procedures are thoroughly coordinated and that resources will match mission requirements.

4.5 Training

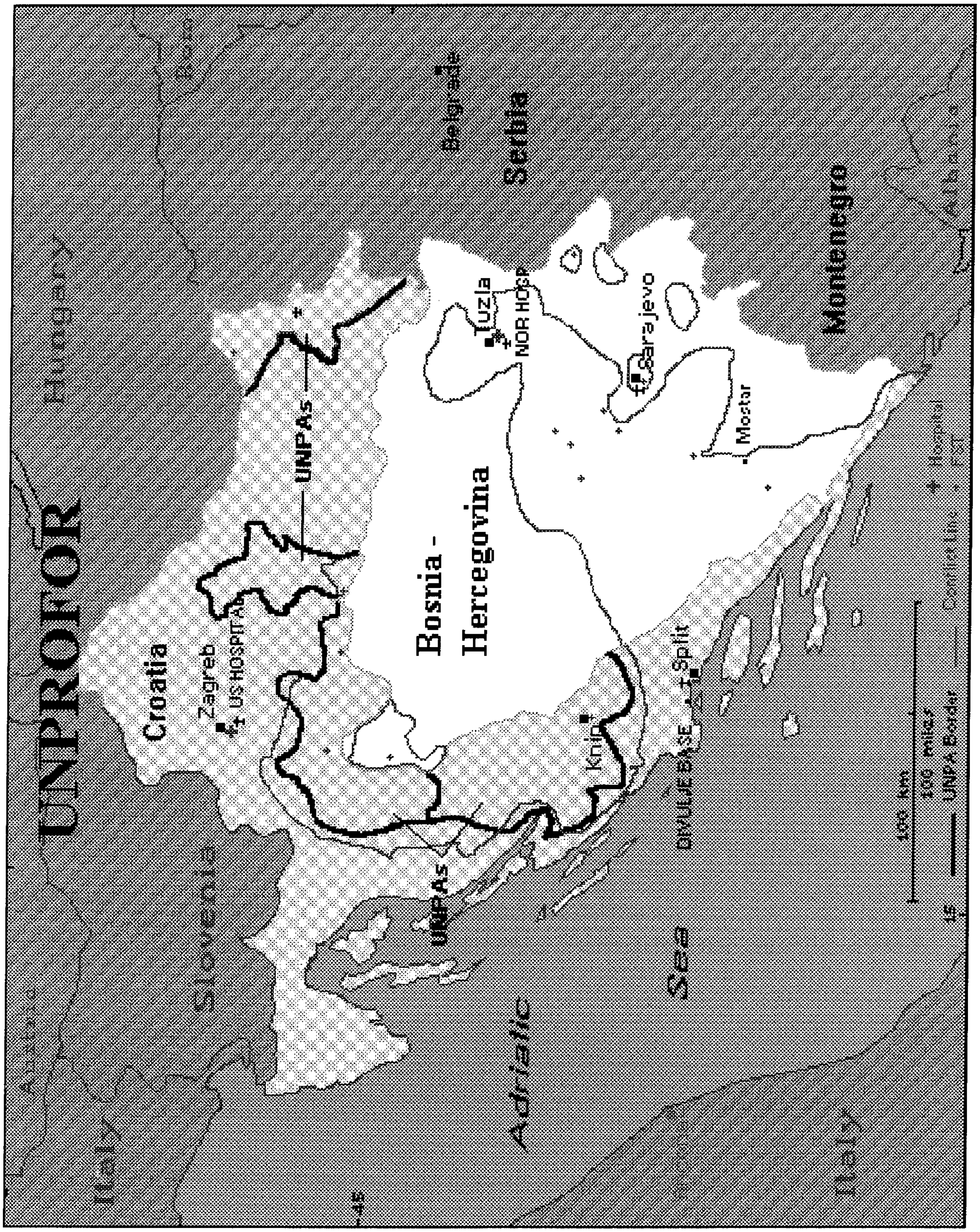
Ongoing training should be aggressively pursued to ensure all UNPROFOR medical personnel are familiar with air evacuation procedures, safety, and capabilities. This training needs to be emphasized for new units rotating into the theater.

4.6 Freedom of Navigation

Negotiation of unimpeded medical evacuation must take a high priority on the political agenda. This should include unrestricted, immediate clearance for all MEDEVAC missions without the risk of hostile fire. Dedicated MEDEVAC aircraft should display red cross markings and insist on the full protection they are accorded under international law.

4.7 Encourage FSTs

Although not a requirement, all contingents should be urged to bring one in support of each major unit. A good MEDEVAC capability will complement the FSTs but never replace them.


UNPROFOR
Hungary
Slovenia
Croatia
Zagreb
US HOSPITAL
UNPAs
UNPAs
Bosnia - Hercegovina
Tuzla
NOR HOSP
Sarajevo
Mostar
Belgrade
Serbia
Montenegro
Knin
Split
DIVULJE BASE
Adriatic Sea
Italy
Italy
100 km
100 miles
UNPA Border
Conflict Line
Hospital

Civil Military Co-operation; a ten year experience of an affiliative aeromedical evacuation programme of the Netherlands Armed Forces and a civilian repatriation organisation

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Introduction.

The increase in the number of peace-keeping activities of the armed forces, and the continuing pressure on national defense budgets, are making a demand for maximum efficiency. Triservice co-operation between army, navy and airforce is being pushed in all areas (not just in the medical area), as well as international co-operation between services and civil-military co-operation.

The need for co-operation and the joining of resources applies to the field of military aeromedical evacuation as well. There is an increasing demand for aeromedical evacuation. This increased demand is due not only to the fact that the military is involved in more disaster-relief operations, (mobile) peace-keeping or peace-enforcing actions than ever, but also to the fact that especially with peace operations optimum quality of care is demanded. We are all aware of the important impact of public opinion in the case of casualties. Optimum quality often can only be realized by prompt evacuation of casualties or sick personnel by air to a high care medical facility, often in the homeland.
Not only in the military field is there an increased demand for aeromedevac. Aeromedevac for civilians is expanding fast. More frequently than ever patients, who are hospitalized in foreign hospitals are repatriated. There is also an increased tendency to use helicopters for primary transportation.

The Netherlands Airforce has also been seeking co-operation in the field of medical evacuation. There is a triservice training programme for medical officers and a small number of family physicians in remote areas to teach them the principles of aeromedical transportation so that they can better prepare their patients for flight. Royal Netherlands Airforce medical personnel attend five week aeromedevac training courses with the Canadian Armed Forces in Trenton, Ontario. And just recently, the Belgian, Norwegian and Netherlands Airforces signed a memorandum of understanding that they may use each others air transport resources.

Apart from these military forms of co-operation, there is the need of close co-operation between the military and various civilian institutions. This short paper focusses on civil military co-operation in relation to aeromedevac in the Netherlands.

Civil Military Co-operation in Aeromedevac.

One area of civil-military co-operation is Search and Rescue and Regional medevac for the Dutch islands in the north of the Netherlands. Here helicopters of the Royal Netherlands Navy and the Royal Netherlands Airforce are used to transport civilians. This is done in close co-operation and support between the Netherlands departments of Defense and Health. Due to a limited time for this presentation I will not elaborate on this subject. Also, the use of civilian aircraft for medevac in case of conflict is beyond the scope of this paper.

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Civil Military Co-operation in Aeromedical Evacuation

Another area of civil-military co-operation has developed between the Netherlands Armed Forces and the University Hospital of Rotterdam. The objective of this co-operation, which started in 1983, was to improve the quality of aeromedical evacuation by promoting research, the exchange of knowledge and by developing training programs.

Rotterdam University medical staff with experience in anesthesiology and intensive care have participated in numerous non-profit medevacs, many of which involved patients in a critical condition. This staff obtained additional training by airforce personnel (flight surgeons, aviation physiologists and pilots) in a special course in aviation medicine, fight safety and organizational aspects. At the end of this twelve hour theoretical and practical training course which included a chamberrun with rapid decompression, all doctors and nurses had a realistic final training in a Netherlands Airforce F27 troopship in medevac configuration to make them feel more comfortable in a flying environment.

The assistance between armed forces and the university hospital works both ways:
flight surgeons of the Netherlands Airforce and the Netherlands Navy receive a three month additional training in emergency medicine. This training is given by senior staff anesthesiologists in the department of emergency medicine of the University Hospital of Rotterdam. Also, military flight surgeons participate with Rotterdam university staff in civilian high care ambulance flights. Thus, flight surgeons were able to discuss clinical problems in various medevac situations and gain valuable experience in aeromedical transport of severely injured or sick patients.

Although in some special cases military anesthesiologists will be on board of our military medevacs, they are not normally considered to be an aeromedical crewmember. We are considering to train our own military anesthesiologists in this respect: in military medevac situations it is often impossible to have civilian aviation-anesthesiologists accompany the flight. At present, the number of specialists in our military hospital is limited.

The civilian organisation uses military expertise and facilities in applied research. The hypobaric chamber is not only used for training of aircrew, hypobaric chambers and aircraft were also used to test equipment performances, such as the testing of a new design of self pressure-regulating endotracheal tube cuffs. All medical equipment such as oximeters, ventilators and bloodpressure indicators were tested as well. Some proved to be inadequate for aeromedevac purposes. Also, the need for more standardization, not only between different military services, but also between civilian and military agencies, became apparent.

Improving aeromedical expertise.

Until recently, Netherlands military aeromedevac was formally limited to stable patients. Experience, both from military as well as civilian flights has shown that it is not possible to adhere to this rule. Emergency evacuation may be the only way to save a patients life as there may not be sufficient time or resources to adequately stabilize patients on the spot. Moreover, on arrival of the ambulance flight, the patients condition frequently proved to be worse than reported. This may be due to deterioration of the patient, insufficient diagnostic tools, insufficient communication or insufficient knowledge of the hazards of aeromedical evacuation. In those cases however it is hardly possible to decide not to take the patient on board when local medical care is not sufficient.

One remarkable observation was the discrepancy in some cases with what flight physiology would expect to happen and the real observations. A striking example for instance is shown by a number of patients with pulmonary injury: we observed in some cases a dramatic decrease in oxygen saturation during rapid descent, although the opposite would be expected by flight physiology. This may be due to a ventilation/perfusion mismatch but the exact reason is still unknown. These, and other observations, emphasize the need for further research in the area of aeromedevac.

These experiences make it clear that thorough knowledge of the peculiarities of transportation medicine are essential. The University Hospital experience with civilian medevac has shown that with advanced medical care it is possible to move almost any patient by air.

Conclusions.

The co-operation between the university hospital and the military has proven to be most valuable in the areas of research and training. Military

Civil Military Co-operation in Aeromedical Evacuation

medical aircrew is now better able to respond to the various problems that may arise in the course of an aeromedical evacuation. The continuation of this co-operation will further improve the possibilities for safely transporting the critically ill and injured. Special attention is required in promotion of standardization between civilian and military medevacs. Accurate recording and reporting of all medevac flights is essential to recognize and correct hazardous situations and to improve the quality of care.

Summary.

In aeromedical evacuation, civilian institutions and the military co-operate in naval Search and Rescue and in the use of civilian aircraft for military purposes. This paper describes the co-operation that has evolved between the Netherlands Armed Forces and the Rotterdam University hospital. Military flight surgeons are trained in Rotterdam in emergency medicine and they participate in high care civilian ambulance flights. Rotterdam University hospital staff is trained by airforce personnel in aviation medicine. Also, Royal Netherlands Airforce research facilities are used. This co-operation ensures optimum quality of patient care in flight by optimum training and research efforts. There is a clear need for ongoing research and standardization in the field of aeromedical evacuation.

AEROMEDICAL EVACUATION BY RNLAF - WORK ACCORDING TO PROTOCOL.

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1. INTRODUCTION

In this presentation the benefit of using a protocol will be clarified. For some two years now the Royal Netherlands Air Force uses a protocol with respect to the following three items: Requesting a Medevac, Selecting the Medical Equipment and Medical crew and Evaluation Rapportation.
The protocol enhances the simplicity and flexibility of aeromedical evacuation.

2. REQUEST FOR MEDEVAC

After accepting a request for aeromedical evacuation by the Head-Quarters RNLAF a lot of improvisation had to be done.
Depending on, for example, the time of the day, some transport-aircraft operations-officer thelephoned his flight-surgeon-on-call.
This flight-surgeon-on-call had to adapt a transport-aircraft for aeromedical evacuation to his own sound judgement.
Making all the preparations, gathering the proper medical information, selecting the medical equipment and medical crew, took quite some time and effort before the use of a protocol.
In our medevac-protocol the chain-reaction from receiving a request for a medevac to actually doing a medevac is properly fixed:

- a. The operations Centre-HQ-RNLAF in The Hague receives a request for an aeromedical evacuation (24 hs duty).
- b. The Operations Centre has to know the number of patients and escorts, the port of embarkation and destination and meeting-times.
  Also the Ops-Centre tries to gather all possible medical information and thelephone/fax-numbers of medical staff making the medevac-request.
- c. The operations-officer of our Transportaircraft Squadron (334 Sq.) on Eindhoven Air Base will get an order to do a medevac. A Fokker F-27 or a Hercules C-130 can be used now.
- d. The flight-surgeon-on-call on the very Airbase Eindhoven will also get his order to do an aeromedical evacuation and will receive a fax with the medical information and thelephone/fax-numbers for more information if necessary.
- e. This flight-surgeon will, in coördination with the assigned Aircraft commander, adapt a F-27 or C-130 for medevac.
- f. Selecting medical equipment has been made more easy by using the standard equipment for all medevac's with all types of air-craft; F-27, C-130, KDC-10 or Chinook-transporthelicopter.
- g. The medical crew of the Medical Services Eindhoven Air Base are all specially trained in Canada for aeromedical evacuation and have a flight-medical check-up every year.

Using this protocol, a fixed chain-reaction on 24-hours-duty, make all preparations for a medevac a lot easier.
Independent of the time of the day the responsabilities are clear.
Civil and Defense-authorities in The Netherlands know that a request made to the Operations Centre RNLAF-HQ in The Hague starts a quick response.

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3. STANDARD EQUIPMENT FOR MEDEVAC

As stated before some flight-surgeon used medical equipment for an aeromedical evacuation to his own judgement.
After evaluating our own experience and having learned from Canadian and American experience we made the standard equipment for medevac.
This standard equipment is suited for use in the Fokker F- 27, Hercules C- 130, KDC- 10 or Chinook-helicopter.
Apart from the varying number of NATO-stretchers the RNLAF-Medical Services uses two sets of standard equipment.
One set consists mainly of nursing-materials suited for 10 patients each.
The second set has to be carried onboard always.
This set consists amongst others of a ECG and Defibrillatorset, an I.V.-pump, suctionpumps, a respirator and a monitor for bloodpressure, Temperature, oxygen saturation, ECG and pulse rate.
Overheadslides show you more detailled our standard medevac equipment.
The two sets mentioned and our "NATO-stretcher-sized" oxygen bottles carrier are suited for all our trans-portaircraft.
So each time the flight-surgeon has a fixed set of equipment knowing the number of patients.
The standard medevac equipment can deal with severe patients and complications during the flight.
These standard is also a benefit for the aircraft-commander: he knwos the size, the weight and last but not least the flight-safety of the electrical devices.

4. EXPERIENCE

The fixed method concerning a request for and doing an aeromedical evacuation according to protocol has been used for more than one year; for example more than 100 patients from Yougoslavia have been transported over Europe.
With the use of our protocol it takes only a few hours from receiving a medevac-request to actually take-off.
As a great many of you colleagues know the number of patients, their medical status or even their destination can change shortly before the flight or during the flight; a stable patient only exists in hospital-wards.
Our equipment covers most of the complications you can expect sometime doing aeromedical evacuations.
The RNLAF made some 30 Medevac-missions from Sarajevo, Split, Zagreb and Ancona.
Our protocol proved to be flexable and complications c.q. acute extra patients could be handled.
Diagnosis o.a.: cardiac failure, C.V.A, orthopedic pathology, oncology, pneumothorax, abdomen surgical pathology, neurologic disorders.

5. CONCLUSION AND RECOMMANDATIONS

A protocol enhances the simplicity and flexibility of aeromedical evacuation with respect to reaction-time, selecting crew and equipment and taking care of complications.
In addition be sure that all Civil and Defense authorities know this protocol.
Finally by using your own standard evaluation- and rapportation-paperwork for the Medical Services and, don't forget, the Operations Centre of your Head-Quarters lessons can be learned from each aeromedical evacuation.
Doing so flying operations will be done and medical know-how will increase trying to reach perfection.

CRITICAL EVALUATION OF AEROMEDICAL EVACUATION IN A MULTINATIONAL FORCES SCENARIO

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INTRODUCTION

A little more than hundred years ago, the injured soldiers were left behind in the battlefield and it was not extraordinary to see wounded still being picked up days after the battle, and then to recieve, if they were lucky, only some degree of wound care and life-saving amputations.

Everyone is aware of the changes that have ocurred in our society following the scientific achievements of the last century. These technical advances have changed the view of our planet. For the first time we realize not only that we are in the same boat, but that we can change it´s course.

Medicine has not turned it´s back to these changes. Todays therapeutic possibilities are far beyond the expectations present just a few decades ago. Those can be made available to any wounded or sick, thanks the progress in transportation, mainly Airtransportation and Medical Airevacuation. However, two facts have to be taken in account:

1. Warfare, with its everchanging situation and hi-tech weapon systems has developed an enormous destruccion potential.

2. Medicine, has become more complex and has to face limited health resources in the military and civilian enviroment. Medical Care and treatment are expensive, complicated and this applies also to med-evac media, especially the ones involved in aeromedical evacuation.

Bearing all this in mind, we describe problems encountered with airevacuations during our involvement in multinational forces and make recomendations after their analisis

PROBLEM DETECTION

We centered our study in the Spanish medical experiences mainly during the last 5 years in NAMIBIA, GULF WAR, ANGOLA, CENTRAL AMERICA, YUGOSLAVIA, and some of the NATO exercises.

Each of these missions had or has specific characteristics and it´s own enviroment, but all had in common the need to interact with forces from other countries usually under the UN or NATO umbrella and to participate in different echelons of medical care and aeromedical evacuation.

We broke-down the Air-evacuation subject into the different concepts involved, examining one by one the main shortcomings detected in each area.

CONFLICTING MEDEVAC ISSUES IDENTIFIED

1.-AIRCRAFTS:

Most of current cargo planes have the capability to be transformed for Air-evacuation means. However, there is a lack of ready available information on what should be ideal capabilities present in these type of planes beside, speed,presurization, ambient noise, vibrations, liter capacity, possibility of water tank and electrical converter

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plaque where to charge and keep fully operational medical equipment, oxygen capacity, etc.. should be adressed and defined.

2.-MEDICAL CARE EQUIPMENT:

The type of equipment, obviously has to bear a direct relationship with the type of mission. But independently of an agressive-interventional, or stable air-evcuation, two goals should be met:

-**Standarization of medical equipment involved**. If that goal can not be met, readily information about different equipments in use and possible adaptors and capabilities should be well known to everyone involved in the mission in order to improve interoperatibility.

-**Type and Amount** of medical material should be normalized as possible in order to make coordination and mission planning more effective.

3.-COMMUNICATIONS:

Communications constitutes one of the cornerstones of any viable project. It multiplies it´s operativeness and is a must in any military mission; in case of Air-Med-Evac, it is vital.

The lack of fluent communications or specific medical channels is an everyday nightmare wich can jeopardise the lifes of our patients and waste valuable resources.

A priority direct medical communication net with interface at any point with IN-area and OFF-area tactical systems and medical Command center, different echelons and resources has to be deployed in any multinational mission. Also a lack of clear guidelines in terms of medical communications, Mission tracking with standarization of messages of arrival, operational status (OPSTAT), mission report (MISSREPORT), etc.., necessary for coordination, can be widely found.

4.-TREATMENT METHODS AND RECORD KEEPING:

Allthought treatment in medicine is similar in most of western countries, in a multinational forces scenario, some types of clinical behaviours and treatments should be protocolized. This would lead to an easier interaction and assure a certain quality of care in any of the Air-Med-Evac teams deployed in a mission.

Also standarized Record-Keeping would make interactions more effective assuring a minimum of information, crucial for patient handling and treatment.

How to assure these objectives is another challenge. Either through international courses and multinational guidelines, where every country participating in a mission, educates it´s own personnel to fulfill those objetives, or through a Predeployment Training Course.

5.-COORDINATION:

Usually there is a section within every headquarters that deals with medical issues; but frequently, it lacks the information or reaction capability needed, and the presence of an inexperienced or capable Medical Officer or Officers. In a Multinational Logistic Command, due to the complexity of medicine and urgency in decision, taking and planning, the presence of an experienced Medical Officer able to evaluate all the data of any situation should be implemented.

The pathways of the Command with the different Health Forces deployed and Air-Med-Evac media should be fluent having alternative information channels always available

6.- PERSONNEL REQUIREMENTS:

This is also a conflicting point, it certainly will depend on the mission and

Medevac doctrine, but certain profile in Air-medevac officer should be pursued:

-Flight Surgeon

-Current clinical skills, with experience in Emergency Medicine, Intensive Care, ACLS, ATLS.

-Experience in this type of missions

-Language skills.

-Medical intelligence and commanding background.

-Hospital based, to assure current training and increased operativeness.

CONCLUSIONS

1.- ADDRESS AND DEFINE THE MEDICAL PERFORMANCES OF EACH CARGO AIRCRAFT

2.-NEED OF UPDATE THE STANAGS OF MATERIAL AND MEDICAL EQUIPMENT.

3.-ENHANCE THE IMPORTANCE OF FLUENT AND UPDATED COMMUNICATIONS.

4.-IMPORTANCE OF EXPERIENCED MEDICAL LIAISON OFFICERS.

5.-IMPROVE THE STANDARD TRAINING OF MEDICAL PERSONNEL INVOLVED IN AIR-MED-EVAC MISSIONS.

6.-LANGUAGE SKILLS.

7.-ESTABLISH GUIDELINES TO IMPROVE MULTINATIONAL INFORMATION.

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EMS-061: EXPERIENCE IN HELICOPTER AEROEVACUATION IN THE COMMUNITY OF MADRID, SPAIN

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SUMMARY:

It's now well-known the fact that in the last few years a new concept of trauma patient medical assistence is imposing itself in the field of emergency medicine. This is helicopter aeroevacuation, and this together with the appropriate coordination between pre-hospital medical care and intensive care units, is making important changes in the desease and death toll of this kind of patients.
The objective of this talk is to transmit the experience of this pre-hospital care service and to evaluate its results and evolution in its first three years of life.

LIST OF SYMBOLS:

CGTB: Civil Guard Traffic Board
EMS-061: Emergency Medical Service-061

EMS-061 ECC: EMS-061 Emergency Control Centre

MD: Medicine Doctor
MH : Medical Helicopter
NHS: National Health Service
NTF: National Traffic Board
RC : Red Cross
RCM: Regional Community of Madrid

RN.: Registered Nurse

After the success of a previous pilot experience in 1990, on March 8th 1991, the so called MH is based in the RCM thanks to a multi-institutional agreement in which the following took part:

- NHS: represented by the 061-EMS, and which contributes medical and nursing personnel, ground support by Intensive Care Ambulances, and medical material, as well as a health network which admits the casualties into hospital that were first treated by the MH personnel.

- NTB: gives the helicopter, model Ecureil AS-350-B1, its maintenance, pilots and spare parts.

- RC Regional Assembly: gives ground support to all the MH interventions by means of its basic life support ambulances.

- RCM Health Board: cares for the economic costs of adapting the helicopter to a medical version with its material and equipment necessary for its medicalization.

- National Government Delegation: holds the presidency of the agreement.

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The main objective of this service, although not exclusively, is the `in-situ' medical assistence by qualified personnel of the injured in traffic accidents, as well as the medicalized transport of those who may need it. Rescue missions and critical patient inter-hospital transfer is also carried out.

Focusing ourselves in the pre-hospital phase, I wish to explain in this talk how the trauma patient care from mainly traffic accidents is made by the EMS-061 medical personnel in the RCM, as well as the features and results of the first three years of the existence of this helicopter medical service.

The crew of the MH is made by the pilot, an MD and an RN. The medical personnel of this service has a training of 1,600 hours in emergency care learned from working in the intensive care, coronary and emergency departments of third-level hospital units in Madrid. In the same way, all the medical personnel is trained in basic and advanced life support techniques.

The helicopter is based in a NTB hangar at the `Cuatro Vientos' Airport, Madrid. The operation zone is the RCM, without excluding the bordering provinces if the situation needs it so.

As a daily routine and before beginning the medical service, the mecanic and the pilot make a helicopter checking, in the same way as the MD and RN revise the medical material and equipment. After doing this the operational condition of the MH is reported to the EMS-061 ECC, RC, and the CGTB.

The MH is operational from 8 am. to sunset. The go-ahead to intervene (activation) is given by the medical team depending on the kind of accident, injured patients' condition and activation procedures, all taken from the data given by the ordinary request sources. These are mainly the RC and the CGTB.

In its three first years of existance, the MH has made a total of 3,272 interventions, 2,166 of which were positive and 1,106 negative. By a positive intervention we mean that in which the medical team assists a casualty whether it is or not transfered to a hospital. On some occasions, previously to the arrival of the team on the scene of the accident, they are informed by radio about the slight degree of injury of the casualties and in this case an RC Ambulance transportation by land is authorised, all of which is considered a positive mission. However, a negative mission is when there is no accident, no casualties or when these have already been transported by private vehicles prior to the arrival of the helicopter.

The number of missions per year has decreased, but on the other hand the rate of positive interventions has gone up thanks to a better coordination and support by the CGTB and RC teams that ask for the intervention of the helicopter in those cases when it is estrictly necessary.

We consider that part of the negative missions cannot be put down on system failures and therefore we are working between acceptable margins by Munich standards.

The average activation time of the emergency team after the alarm is given is 3 minutes, which are taken up in starting the helicopter, asking for data and permission for take-off from the control tower. The average time of arrival on the scene of the accident is 14 minutes, 30 seconds, at an estimated average speed of 200 km per hour (equal to 110 knots).

When the medical team arrives at the place there are many occasions in which the casualty is trapped inside the vehicle. In this case and prior to his mobilisation, the team tries to get to his side and proceed to estabilise him by controlling airway permeability, securing an intravenous access for volume replenishment and controlling intense pain if necessary. Also, a general assessment of the presenting pathology is made.

Mobilisation of the patient is carried out under estrict measures with the aim to avoid an agravation of possible spine injuries. To do so, cervical collars and spine inmobilisers are applied before the extrication of the patient takes place. Afterwards the patient is laid on a rigid articulated and folding stretcher.

Once the person has been freed an overall assessment is made with especial attention to the vital signs. After checking the airway permeability the patient is given proper oxigen ventilation if necessary, or even orotracheal intubation in the case of acute respiratory insufficiency, in patients having an equal to or minus 8 value in the Glasgow scale and whenever shock can compromise the later ventilation of the patient.

The techniques used for the control of the circulatory system are the volume replenishment and the handling of active hemorrhage. Venous access is usually peripherical by means of high calibre angiocatheters and only in those cases when this access is not possible a central catheter is used.
Measuring the blood pressure and palpating the peripheral pulse allows us to control the volume replenishment until the patient reaches the hospital.
In the event of cardiopulmonary arrest advanced CPR procedures are carried out `in situ' or during transport.

The neurological assessment is made using the Glasgow scale. In the event of patients with a high degree of agitation or severe trauma that can worsen their anxiety we use short mean life benzodiazepines and opiacium derivates.

In the last place and prior to the transport of the casualty an inmobilisation of orthopedical trauma is made using inflatable splints once the traction and alignment of the fractured limb has been achieved.

In this period of three years a total of 2,855 casualties have been treated, out of which 1,024 were transfered to hospital centres.
The average time of medical treatment given to an injured person in each mission in 1993 was 24 minutes, 24 seconds, whilts in 1991 it was 15 minutes, 30 seconds. This time has increased in accordance with the more severe pathology for which we are now requested to act that demands itself longer time for overall assessment and estabilising techniques.

During transportation vital signs are continously checked, as well as ECG and hemoglobine saturation monitoring. This data and a patient's pathology report is transmitted to the EMS-061 ECC in some cases or other directly to the hospital.

The average transportation time is 12 minutes at an estimate speed equal to the arriving speed.

In the case of the destination hospital not having a direct access between the heliport and the emergency department area, we are provided with an EMS-061 Intensive Care Ambulance that is in charge of the patient's medicalised transport from the heliport to that emergency area. This average time of transfer between helicopter and ambulance or hospital is 5 minutes. And this much reduced time is due to the excellent coordination between the medicalised helicopter and the EMS-061 ECC that leads the ambulances to the hospitals' landing platforms.

Once the transfer has been completed the helicopter flies back to base to get supplies of material, medication and for clean-up. If this were not possible due to a new activation the helicopter carries a reserve of material, medication and intravenous fluids so that a new assistance will not be delayed.

The medical service is concluded at sunset each day, and that is when again this is reported to EMS-061 ECC, RC and CGTB.

We would like to thank the help and great colaboration shown by members of the CGTB, RC volunteers, and we are also very grateful to all who in a direct or indirect way are making this kind of assistence possible in the community of Madrid. We also want to outstand the initiatives that are being taken to extend this service to other parts of Spain.

AEROMEDICAL EVACUATION IN COMBINED OPERATIONS

by

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The Gulf War (Desert Shield/Desert Storm) was a military effort involving multinational participation on a scale unparalleled in the history of modern warfare. Numerous countries were involved in the operation--many providing combatants. The nature and scope of the allied involvement led to numerous interoperability issues in many areas, including medical. United States forces were deployed in accordance with an existing operational plan (OPLAN) which had been developed to counter an Iraqi threat to Kuwait and Saudi Arabia. That OPLAN included the development of a theater medical system (TMS) to support all components of the US military. The details of the relationship between US forces and its allies were not part of that OPLAN and evolved as deployment of forces took place. In order to resolve interoperability issues, Friendly Force Medical Conferences were conducted during the course of the war. Senior medical officers from the allied forces gathered together to resolve areas of concern. There was considerable variation in the medical capabilities of the deployed allied forces--particularly as it related to aeromedical evacuation. It was crucial that a clear understanding be developed as to how that particular mission was to be conducted. A Friendly Forces Patient Disposition Interoperability Plan was drafted to provided guidance as to how patients from the various allied fores were to be managed within the TMS. The management of special categories of patients, such as displaced civilians and enemy prisoners of war had to be dealt with as well. The challenges presented by the multinational effort were dealt with in an atmosphere of cooperation and a desire to establish a workable system. Immediately after deploying to Saudi Arabia, medical leaders from the U.S. military's four major components-Army, Navy, Air Force, and Marines working with the U.S. Central Command Surgeon met to coordinate efforts in establishing the TMS. Such joint efforts have been greatly emphasized within the U.S. armed forces in recent years. 'Joint' being defined as activities involving two or more components. The interservice cooperation and coordination, that have resulted have lead to greater cost savings and enhanced combat effectiveness. It became obvious to the medical leadership that Desert Shield/Desert Storm would be an international effort involving a coalition of many nations. We were now dealing with a combined operation, rather than simply a joint one. The term 'combined' refers to a military activity, exercise, or operation involving two or more nations. Some of the participating nations had exercised with U.S. medical forces previously, many had not. When the military personnel from the participants deployed, they brought their medical support as well. Such support varied widely in terms of number and capability. On the occasion of the first of several Friendly Force Medical Meetings mentioned previously, the medical leaders of each nation briefed their personnel status, equipment, and aeromedical evacuation assets. Capability varied widely. It was evident, however, that some participating nations had not developed an air evacuation capability or had exercised that contingency.

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For example, some had C-130s in their inventory, but had not obtained the necessary hardware for configuring for air evac. Development of an overall plan of cooperation began immediately, but was refined constantly as the combat and support forces were located and relocated as needed within the theatre. Many deploying forces had no rotary or fixed wing air evac platforms and limited surface evacuation assets. A plan to insure that all were covered was devised. An elaborate aeromedical evacuation system was established within theatre and included five major air heads for interfacing tactical and strategic systems. In order for an aeromedical evacuation system to work effectively and efficiently it is necessary to have these basic elements in place: an effective means of communication, a system of resupply, a common approach to battlefield casualty management, compatible equipment, a clearly defined concept of patient flow, well trained air evac crews, and a means of tracking patients through the system. Deficiencies were encountered in each of these elements during the Gulf War and had a negative impact on combined medical operations. There was no common means of communication. There was no common system of resupply - each country was basically on it's own. Approach to casualty management varied somewhat. A copy of the NATO Handbook "Emergency War Surgery" was provided to each senior medical leader, but was too little too late to establish a common approach to wound care. Equipment was diverse and in many instances incompatible. The patient flow pattern was quite well defined, but breeches still occurred. Air evac training was often deficient, if not non existent. There was no reliable means of effectively tracking patients. Aeromedical evacuation planning should encompass the entire spectrum from battlefield casualty management to tactical and strategic evac. A well developed preplanned concept of operations will reduce risks to personnel and equipment and result in a saving of money and lives. Through the intense efforts of all medical personnel the system worked, but it was far from optimal. Multinational efforts as seen in the Gulf War, Bosnia, Somalia, Rwanda, and Haiti are examples of what we're likely to see more of in the years to come. Whether peacemaking, peacekeeping, or engaging in combat, combined operations are clearly in our future. A preplanned approach to air evac is essential. A prime requirement should be that every nation should possess an aeromedical evacuation capability. Ideally, such a capability should be able to be tasked in wartime to support a multinational operation with an absolute minimum of training and modification. Through organizations such as AGARD these issues can be dealt with. However, the range of today's international involvement goes well beyond NATO. We all realize that preplanning and detailed preparation are limited by funding and lack of opportunity to train. Matters are complicated by uncertainties relating to international politics and military doctrine. Combined exercises are absolutely essential and must be encouraged. International meetings such as AGARD and the Aerospace Medical Association should be used to keep concerns relative to air evac in combined ops fresh in everyone's mind.

Danish Aeromedical Evacuation Efforts during The Gulf War

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1. SUMMARY

During the Gulf War 1990/1991 a Boeing 737-300 was leased from a civilian airline company and prepared for aeromedical evacuation of injured allied soldiers from US bases in Saudi Arabia, or from staging facilities in West Germany or England, to Holstebro Military Hospital in Denmark.

Additional fuel tanks and military communication, navigational and identification systems were installed.

The original interior was replaced with stretcher racks placed along the cabin wall on both sides together with intensive care medical monitoring equipment.

Object was to operate 24 hours a day, and three medical crews were established.

Patient selection, categorization, prioritization and loading plans would be decided by a Senior Flight Surgeon in a forward position.

After 3 weeks, on February 8., 1991 the system was declared operational, and a test flight to Rhein Main AB, Germany was accomplished.

Though the system was never activated due to the limited number of casualties, valuable experience was gained, and the system should be considered in connection with future international military operations.

2. BACKGROUND

During the Gulf War in 1990/1991, part of the Danish contribution was in the medical field. This consisted of three parts :

A group of 30 medical personnel, including surgeons and anesthesiologist, was sent to enhance the surgical capability of a British field hospital in Saudi Arabia.

A United States Air Force (USAF) Contingency Hospital in Denmark was activated, staffed with Danish personnel, and brought up to contemporary standards in all respects. It was named Holstebro Military Hospital (HMH) and was situated in the western part of Denmark.

An aeromedical evacuation unit was formed, to provide transport of patients to HMH.

The latter part will be the subject of this paper.

3. SUMMARY OF EVENTS

The mission to provide aeromedical evacuation support to HMH was given to Medical Squadron 590 (590SQN) at Vaerloese Air Base. The first warning was given by the Surgeon General of the Danish Armed Forces Medical Services on January 10th, 1991. 590SQN was ordered to prepare for acquisition of a suitable stretcher system and other equipment to convert a civilian airliner to an Aeromedical Evacuation aircraft capable of transporting 40 stretcher patients. Additionally, we should prepare selection and training of medical crews in sufficient numbers to allow continuos operation of the aircraft over a longer period of time.

After the airraids of Operation Desert Storm had started on January 15th 1991, the Danish government passed the necessary legislation to allow Danish participation in allied operations in the Middle East.

On January 17th, 1991 the Air Force Materiel Command signed a contract with a civilian Danish airline company to lease a Boeing 737-300, and conversion of the aircraft from its normal configuration to an aeromedical evacuation configuration started.

At the same time the commanding officer of 590SQN was sent to Germany to arrange details of co-operation with the US 17th Air Force Surgeon General, concerning selection of patients for HMH from the Aeromedical Staging Facility at Rhein-Main AB, Ramstein AB or Upper Heyford AB. It was agreed that the patients would primarily be selected among the patients transported to one of these locations from the Middle East by USAF aircraft.
However, the aircraft did have the capability to fly non stop from Saudi Arabia to Denmark.

It was agreed to send a Aeromedical Liaison Team to Rhein-Main AB to cooperate with the American aeromedical evacuation system, to help select patients for HMH and to make a loading plan for the aircraft

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before its arrival. The Aeromedical Liaison Team consisted of the commanding officer of 590SQN, a medical corps CMSgt and a MSgt. The liaison team remained at Rhein Main AB until February 21st.

On February 8th, the system was declared operational and a demonstration flight was completed to Rhein-Main AB to test the system and demonstrate it to the Americans there.

In the following weeks the aircraft remained in readiness with a flight crew and a medical crew on standby on base, a second crew on 1 hour standby and one crew resting. The time was spent refining the equipment, adding further training of the medical crews and documentation of the entire system for later use. Exercises were carried out with loading and unloading of simulated patients and transporting simulated patients to HMH.

On request from the British armed forces, the aircraft was also offered as a supplement to the British aeromedical evacuation system, intended to fly patients directly from the Gulf-area to the United Kingdom.

Loading and unloading of the aircraft could be carried out from both sides of the aircraft, using any sort of platform that could be raised to the door. In Karup two covered platforms were constructed using cargo pallets from a C-130 with railings and a cover. These platforms could be mounted on heavy forklifts and raised to the aircraft door, where one or two stretchers could be lifted onto the platform. The platform would then be lowered and turned to the waiting ambulances. Transport from Karup AB to HMH was provided by 12 army field ambulances and 3 air force intensive care ambulances for the critical cases. SAR helicopters were available in very critical situations. Military police provided escort for the ambulances on the route to HMH.

An Aeromedical Staging Facility was set up in a hangar at Karup, for the unlikely event that it would be necessary to stabilize patients before ambulance transport to HMH, a trip of 30 to 45 minutes.

4. THE AIRCRAFT

The outside color of the aircraft was white, and red crosses were painted on both sides of the aircraft, on the upper and lower surfaces of the wings and on the tail. The aircraft was registered with the civilian call sign OY-MMD. This way clearance to fly over neutral countries could be obtained more easily.

Inside the aircraft passenger seats were removed, additional fuel tanks were installed in the cargo bay to increase the cruising range, and military radio identification and communication systems were installed to enable identification and entrance into the military controlled air space in the Middle East.

5. THE CABIN

A stretcher system was acquired from the Norwegian Coast Guard and transported to Denmark. Upon arrival several modifications were carried out to reinforce the structure, in order to comply with current aviation regulations for air worthiness. These modifications included changing all existing bolts with bolts of a stronger alloy, and mounting of a support post between the lower and middle stretcher supports in those stretcher racks with 3 stretchers on top of each other. The stretcher racks fitted into the existing rails in the floor, and were installed along the cabin wall in both sides.

The first three racks on the right side and the first two on the left side consisted of only two litters on top of each other and were reserved for critically injured patients, requiring intensive care and observation. The rest of the racks consisted of three stretchers on top of each other. This configuration would allow transportation of 40 stretcher patients and 9 sitting patients/escorts, but could easily be changed within an hour to a configuration of 31 stretcher patient and 33 sitting patients/escorts.

Two Oxylog pressure controlled, portable ventilators and 2 Propac cardiac monitors with built in blood pressure and temperature gauges were acquired along with 1 pulsoximeter and an extra electronic blood pressure gauge. Eight Laerdal suction devices (pressure or manually operated) were added to the aircraft from the supplies of 590SQN, along with two oxygen racks, each holding four 10 liter (200 Bar) oxygen bottles. Oxygen outlets and suction devices were distributed along the stretcher racks.

The medical equipment was stored in the containers and trolleys in the front and rear section of the aircraft, normally used for catering purposes. These were converted to functional units, and could easily be transported to the position where they were needed. Three identical sets were prepared, to allow quick turnaround of the aircraft by simply replacing the trolleys and containers with a fresh set. Overhead compartments were used for storage of additional equipment.

6. THE MEDICAL CREWS

With some delay due to misunderstandings, recruitment of medical crews for the aircraft was started on January 25th, and the personnel reported for duty on February 1st on Vaerloese Air Base. A total of three crews were recruited, each consisting of 2 Physicians, 2 Nurses and 3 Aeromedical Attendants. The physicians were recruited among Air Force reserve Flight Surgeons, the nurses were recruited from civilian hospitals and the technicians were recruited among recently educated drafted personnel, who volunteered

to sign up for this mission. The physicians were selected so that each crew would have one Flight Surgeon with anestesiological experience and one with surgical experience. One of the nurses would be a anaestesiologically trained nurse and the other would have experience from a Intensive Care Unit. The most senior of the Flight Surgeons would be in command of the medical crew.

All personnel passed a medical examination for cabin crews including pertinent immunization, and were issued standard military equipment, including flight gear and NBC gear. The personnel received an abbreviated flight medicine course, NBC-training, physiological training including hypobaric chamber training and an aircraft specific Cabin Attendant course to teach them to operate the aircraft's emergency exits etc.

During this period of training conversion of the aircraft was completed and the aircraft was stationed at Karup Air Base, approximately 30 km from HMH. The crews were transferred to the same location, along with a senior sergeant and an ambulance driver from 590SQN to help maintain the medical equipment for the aircraft and handle supplies.

7. EXPERIENCES

The stretcher system used is very flexible, since it is mounted in existing rails in the aircraft, normally used to hold the passenger seats. Thus, a large variety of aircraft can be fitted with this system.

The cabin of a civilian airliner provides a quiet, well ventilated environment with good light conditions. In the described configuration there is ample room for observation and treatment of patients en route.

Although the aircraft was never needed to provide aeromedical evacuation during the Gulf conflict, due to the limited number of casualties, valuable experience was gained. Currently, Denmark is preparing a brigade of 4.500 soldiers to be part of NATO's Rapid Reaction Forces, and it will be necessary to develop a concept for aeromedical evacuation support for this brigade if it is committed far away from Denmark. The Danish Air Force does not have sufficient capacity for this mission in a situation with effective peacetime conditions in Denmark, where evacuation over long distances in the cargo bay of a C-130 is not considered satisfactory. We believe our experiences from the Gulf conflict can form the basis for a system based on converted civilian airliners, which could be transformed into an aeromedical evacuation configuration within a few days. Three or four such aircraft would be needed to support the brigade in a combat situation, and the stretcher system and medical hardware would have to be acquired and be maintained by the medical squadron assigned to the task. A sufficient number of medical crews of a similar composition as during the Gulf experience would have to be appointed among mainly reservist personnel, and their training would have to be maintained through regular exercises. A final decision to form such an aeromedical evacuation unit has not been taken at this time.

We consider it essential that the aircraft(s) are organized, staffed and operated by the Military, and not by a civilian organization. It is necessary that aircraft, medical crew and medical equipment composes an integrated system, which is already organized and trained in advance. When the system is activated, it is necessary that the aircraft is a Military responsibility (insurance) and that all crew members are under Military command. A civilian organization can not guarantee operation of the aeromedical system under combat conditions, and it will be difficult to obtain insurance of a civilian aircraft under such conditions.

EXPERIENCES LEARNED FROM THE SPANISH ARMED FORCES AEROMEDICAL EVACUATION SYSTEM IN THE FORMER YUGOSLAVIA

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INTRODUCTION

During the last two years, Spain has participated as a part of the United Nations Forces in the former Yugoslavia.

The Spanish Forces bore a major responsibility for mantaining the acces of relief personnel and supplies to the areas designated to them, especially arround Mostar and the Neretva valley.

Medical personnel from the Army accompanied these forces stablishing certain sanitary objectives and implementing their Medical deployment plans. Which consisted in a small clasification post in Dracevo with an ICU with surgical Unit (1 Surgeon, 1 Orthopaedist, 1 Anestesiologist, 1 Intensivist,etc..) and a few hospital beds and 4 ambulance teams each with a doctor and a nurse on board.

As the first cassualties occurred, the aeromedical evacuation plan was activated.(this task was "commended" to the Air Force Med-Evac Teams). These teams had some relatively recent experience drawn from operations in Namibia and south-west Asia in the last years. But the real scenario, taught new lessons which had to be assimilated, and the conclusions drawn implemented to improve our operational activity.

There is no doubt that Medical Aeroevacuation is nowadays an universal need accepted by not only the military, but civilians. The increment in multinational operations, that often takes place in remote areas, far from the usual location of the units, makes it neccessary to have the medical perssonnel and equipment ready to repatriate or to transfer casualties to more adequate treatment centres.

CURRENT CONCEPTS IN AEROMEDICAL EVACUATION

The primary mission of the Spanish Air Force Aeromedical Evacuation System is to provide medical airlift to wartime casualties , and , in specific cases to civilians when needed.

The Air Force has the capability to provide tactical and strategical evacuation, with the use of PUMA and SUPERPUMA helicopters, CN-235, C-130, FALCON 900 and B-707 aircrafts; Navy and Army also have tactical medevac capabilities thanks to their helicopters.

The structure and objectives of this system have changed after their experiences in Namibia and the Gulf war.

After analizing possible combat casualties, it was decided during the Spanish participation in the Gulf conflict to provide the Med-evac aricrafts not only with Flight nurses, but also with a physician. The number of technicians were substituted by nurses whose skills proved more operational.

Medical equipment on board was also upgraded to be able to occasionaly evacuate unstable patients; as the espected flow of casualties could at some point over helm the

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aeromedical staging facilities or the intratheatre medical treatment facilities.

We knew that during any wartime situation, airlift, because of its speed and flexibility, will be the priority method of transport. A plan to use civilian aircrafts to be reconfigured to an AE mode is not operational at this point and all the medical Air-Evacuation efforts have to rely on Air Force capabilities.

As soon as we became involved in the Yugoslavian conflict, we realized that often the recuperation and treatment of wounded could not be accomplised intratheatre because of limitation and overcrowding in the civilian hospitals in the area, and the logistical limitation of Army medical units deployed there.

Therefore, the Medevac system was again upgraded and prepared to transfer unstable patients wherever needed. A certain number of critical beds were planned in the configurations of the different airplanes used for these purposes, mainly CN-235 and C-130.

We believe that this evolution in the care and transportation of injured is justified the technical developement of all the support equipments.

Today, warfare, because of the caracteristics of the technological advance, can confront the medical system with a new anddifficult situations. Especially in the area of conflict where a flow of casualties can easily over helm the local facilities. This situations requires a new aproach to aeromedical evacuation. The task is not only to transport stable patients, butthe real situation often requires the evacuation of unstable or critical patients; and in certain cases, even the direct intervention in the operational theatre with it's medical capabilities either as a direct support to the force or to local structures. This policy does not invalidate the principle of transporting stable patients whenever this is possible, but it offers the possibility of an alternative when the local scenario demands critical evacuations.

The critical evacuation has already shown positive results not only in our experience but to our understanding, in U.S. operations in Panama. It had alrready proved very beneficial in civilian ground transports where the presence of physicians in fully equipped ambulances, has proven far more effective critical cases than the usual technician runned ambulance system or in helicopter assisted with a physician on board in traffic accidents.

OPERATIVE PLAN

To fullfill these objectives, during the Yugoslavian crisis, three aeromedical evacuation teams, recently increased to four, have been ready to deploy within 2 hours activation time frame.

As soon as the Air Force gets the request from the Army operational command for the airlift, it activates the aeromedical evacuation officer on call at the Central Air Force Hospital who will:

.Activate the first evacuation team
.Put on standby the second team
.Stablish himself as chief ofoperations and control, until the mission ends
.Acts as a liaison officer to provide more additional aircrews and aeromedical facilities, if needed.

.Provide current information to Military hospitals and arrange transportation of arriving casualties to the medical treatment facilities.

Because of this location he is able to activate additional Medical

specialist support if needed, from the hospital staff.

HUMAN & TECHNICAL RESOURCES

Each team is formed by 1 Flight Surgeon, 1 Intensivist (optional), and 3 flight nurses; all of the members of the teams ar active in the Air Force Hospital and mantaining all their skills updated. Usually all the medevac training is done aside from their everyday duty, on weekends and after hours.

This medevac capability does not interfere with the Hospital activity except for the no-play situations and only takes its roll on the free-time of the team members. These members are always volunteers and do not get any special economical, advantages or any other type of compensations except for their professional and human satisfaction. Special training and profile is requested for the team members.

The Flight Surgeons besides his Medical or Surgical speciality, has to be current in ACLS, ATLS, emergency techniques, and trained in Aeromedical Logistics and war medicine.

The Intensivist is part of the ICU service keeping also his skills up-to-date in his everyday duty.

Each of the three nurses of the team is expert in one of the three different areas: Medical, Surgical and Trauma, and besides their daily activity in their areas, also have to fulfill mandatory rotations in the OR and ICU to keep their interventional skills current.

During the Yugoslavian operations, there were three operational teams aviable 24 hours and able to fullfill all the missions that were requested with success. This was a hard task, but at the same time allowed us to gather more experience and knowledge. Recently a fourth team was incorporated.

The structure of these teams is not rigid, accordingly to missions, number and degree of casualties, additional physicians or nurses from the other teams or other especialists may be requested, allthought the minimal medical force in the airplane is always restricted to one team, you are never sure if the situation will have changed at your arrival.

The technical equipment in the planes depends on the type of airplane, the potential number of casualties and the type of mission, but each plane has a standard amount of equipment ready to operate that allows patient care under normal and critical circumstances; including:

- Monitor
- Defibrillator-pacemaker
- respirator
- Aspirator (mechanical and electrical)
- Pulse-oximeter
- Perfussion pumps
- oxygen in bottles
- Antishock garments
- Medication and material needed for standard mantainance and resucitations efforts

In the case of Spain, because of media limitations, additional flexibility had to be achieved in order to provide intratheatre support if needed, therefore some additional medical equipment and supplies is taken with the team, allowing part of the team to remain in the area for operational support while the other physician with the remaining nurses would fly back with the med-evac casualties.

These teams also constitute the basis of the Air Force Medical intervention Units with fouer additional physicians and nurses and a portable surgical unit with some additional equipment. These units can be deployed to conflict areas with a minimal reaction time and therefore provide almost innmediate support in crisis situations.

RESULTS

Seventeen missions have been accomplished from January 1993, in wich 30 casualties has been evacuated by our Air-med-evac Teams. The clasification by its prognosis was: 8 T1, 12 T2 and 10 T3. The basic diagnosis were: 5 head trauma, 10 abdominal trauma, 3 toracic trauma and 12 extremity trauma.

There were no inflight deaths.

DISCUSSION

The intra or inter-theatre, Aeromedical evacuation, provides 3th and 4th echelon medical support. The casualties triage can include T1 and T2 patients on-board if the medical crew trainning, medical equipment and aircraft are adecuate.

From our first mission with WEU during the Gulf Crisis, we have updated the concept of needed personnel and reselected the medical material and aircraft for stable and unstable casualties transportation to prevent the case of insufficient medical facilities in the conflict area. This philosophy agrees with the USAF doctrine change after their experiences during the Beirut crisis and "Just Cause" operation (Panamá).

The cooperation with other allied forces is small; Superpuma and Sea King helicopters from the French Army and Royal Navy provides tactical Air-med-evac to our soldiers from Dracevo to Split airport. Each Country is using his own med-evac chain.

We believe that increased effectiveness and optimization of resources could be achieved through an integrated multinational command.

CONCLUSIONS

1.- NEED FOR AIR-MED-EVAC IN OUT OF ZONE OPERATIONS.

2.- TRAINING OF MEDICAL CREW AND LIFE-SUPPORT EQUIPMENT ON BOARD FOR UNSTABLE WOUNDED TRANSPORTATION IF NEEDED.

3.-STABLISH AND MANTAIN A MULTINATIONAL COMMAND.

4.-KEEP IN STANAGs POLITICS ACCORDING WITH EACH COUNTRIES POSIBILITIES.

RE-ENGINEERING SUPPORT TO THE PATIENT MOVEMENT PROCESS

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SUMMARY

The complexity and dynamics of medical evacuation planning - for peacetime, wartime, and disaster scenarios - require decision support aids that provide much more than data base access and spreadsheet solutions. This paper presents an overview of the development and early user operational and technical assessment of a Decision Support System (DSS) that incorporates innovative object-oriented data bases, state-of-the-art mapping capability, and constraint-directed planning technology.

1 INTRODUCTION

In 1993, the United States Transportation Command (USTRANSCOM) assumed global oversight for worldwide intertheater medical regulating and aeromedical evacuation. Previously, medical regulating and aeromedical evacuation were managed by separate organizations, had different procedures for wartime and peacetime, and had no standardization or connectivity between theaters.

To correct these deficiencies, USTRANSCOM's Commander-in-Chief was designated single manager for Armed Services Medical Regulating and assigned four key responsibilities: control of the Global Patient Movement Requirements Center, regulation of global movement of patients, acquisition/training of deployable medical regulators, and development of a centralized command and control (C^2) system for global patient movement providing theater wide integration and connectivity as well as offering patient by-name intransit visibility in peace and war.

Working closely with all levels of the Department of Defense, USTRANSCOM's Surgeon is developing TRANSCOM's Regulating and Command & Control Evacuation System (TRAC²ES). TRAC²ES was aggressively prototyped by capitalizing on software developed by the United States Army to track and distribute munitions in Europe.

As the medical element to USTRANSCOM's overarching C^2 system called GTN, the Global Transportation Network, TRAC²ES provides three major data pieces: patient information requirements, receiving medical treatment facility capability, and patient transportation capability. TRAC²ES also checks worldwide the status of patient movement items (e.g. litters, portable ventilators, etc). This information, processed through GTN, provides USTRANSCOM the capability to monitor current operations and plan future patient movements. As TRAC²ES fully matures, it will consist of a Global Patient Movement Requirements Center, Theater Patient Movement Requirements Centers, predominantly in the European and Pacific theaters, and deployable TRAC²ES to support continental United States disaster relief efforts and other global locations such as the Middle East and Asia, not supported by established Theater Patient Movement Requirements Centers. The success of TRAC²ES has reached international acclaim and become the model for intratheater patient regulating and evacuation. This means once patients are admitted to battlefield medical treatment facilities, processes of locating appropriate fixed medical treatment facilities, in and out of the theater of operations, begin. By the time patients are prepared for further movement, appropriate destination and airlift assets are identified to efficiently balance capacity to critical demand.

TRAC²ES is an emerging, state-of-the-art DSS with a rich interactive graphics and map-oriented user interface with an underlying powerful planning/scheduling algorithm. TRAC²ES has been designed, and is being implemented, to be used by "Evacuation Brokers" to match transportation lift capability and medical treatment facility beds with patient medical treatment needs, i.e. to plan, replan, and monitor patient evacuation. TRAC²ES will identify potential bottlenecks and shortfalls in evacuation assets, provide guidance on how to relieve those choke-points, and serve as the vehicle to provide in-transit visibility of individual patient moves.

TRAC²ES will support world-wide and/or theater-wide Evacuation Brokers to rapidly prepare and evaluate evacuation plans to support peacetime, disaster (earthquake, hurricane, etc.) and wartime contingencies. These plans may be developed against future contingencies or in direct support of patients in a disaster area waiting for rapid evacuation. TRAC²ES will also serve as an on-line near-real time tool to plan and schedule normal day-to-day operations. Hence, it will provide a tool to enable seamless graceful transition from peacetime to emergency scenarios without time delays and train-up for a different mode of operation as is currently required.

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TRAC²ES represents a substantial advance in graphical interactive planning tools, with the inclusion of intelligent planning algorithms that provide a powerful adjunct to the planning skills of evacuation planners. TRAC²ES has been designed and implemented as a DSS, based on the recognition and appreciation of how complex and challenging the evacuation planning problem is, and how many subtle and interacting factors and considerations must simultaneously be brought to bear in solving these kinds of problems. The TRAC²ES algorithm builds evacuation plans which deal first with patient care (medical need, urgency, special handling), while also focusing on cost-effective use of available aircraft and medical assets.

2. INDEPTH OVERVIEW

As the USTRANSCOM Surgeon's Staff undertook the complex task of re-engineering, a remarkable concept emerged. The concept was integration of medical regulating (beds) and aeromedical evacuation (lift) for "one-stop shopping." The logical by product from this process was the introduction of the "lift-bed" concept. The evolution of the lift-bed concept was seminal because it considers the *entire* set of lift and bed resources, and offers a single, integrated patient movement solution.

"Lift" is defined to TRAC²ES as not just the physical aircraft but the entire transportation scope - transportation assets, and so on. Similarly, "bed" entails not just the physical bed but also the medical treatment facility medical staff, expendable medical supplies, reusable medical equipment, and so on. Because TRAC²ES integrates all lift-bed resources, its plans and schedules will represent more accurate patient movement solutions.

As patient movements are planned and executed, TRAC²ES will support patient by-name intransit visibility. Patient information entered in the Theater Army Medical Management Information System , Distributed Health Care Program, and Composite Health Care System hospital management information systems will be combined with transportation mission data from the Global Transportation Network. Authorized personnel will be able to dial into TRAC²ES and obtain a patient's itinerary and actual location, while authorized medical personnel will be able to obtain a patient's itinerary, actual location, *and* limited medical information.

3. INFORMATION FLOW BETWEEN ORGANIZATIONS

TRAC²ES supports the notion of a centralized Global Patient Movement Requirements Center coordination with decentralized Theater Patient Movement Requirements Center execution. That is the Theater Patient Movement Requirements Center has been delegated authority for inter-theater patient movement planning and execution with the boundaries established by the Global Patient Movement Requirements Center. If the Theater Patient Movement Requirements Center needs additional resources, it requests them from the Global Patient Movement Requirements Center. As necessary, the Global Patient Movement Requirements Center arbitrates contention for assets and requests additional assets from lift and bed providers in collaboration with affected Theater Patient Movement Requirements Centers.

Data and Distributed Collaborative Planning

TRAC²ES data includes bed, lift, and patient data, as well as theater and global plans and schedules. To support collaboration between Theater Patient Movement Requirement Centers and the Global Patient Movement Requirements Center, both will share access to the same data as they generate their plans and schedules. Furthermore, the Global Patient Movement Requirements Center will be able to view Theater Patient Movement Requirements Center plans and schedules during collaborative sessions to create its global plans and schedules.

Audio/Video

Audio/video links will be installed between the Theater Patient Movement Requirements Centers and the Global Patient Movement Requirements Center. During daily (or more frequent, depending upon circumstances) planning and scheduling collaborations, real-time video-conferencing will be critical to help the Global Patient Movement Requirements Center and Theater Patient Movement Requirements Centers quickly and effectively converge on plans and schedules. During emergencies, video-conferencing will probably be active 24 hours a day.

Fax, Voice

Telephones and facsimile machines will also be used by the Global Patient Movement Requirements Center and Theater Patient Movement Requirements Centers. However, given the interactive nature of command and control, the preferred means of communication is likely to be data/audio/video.

4. MODES OF OPERATION

TRAC²ES will accommodate three modes of operation: Deliberate Planning; Forecasting; and Reactive Replanning. Since this paper provides a high level overview of TRAC²ES, these modes are described as if they are discrete. In reality, they occur concurrently. Furthermore, the patient movement schedules of the Forecasting mode and the patient movement manifest of the Reactive Replanning mode are not static entities: constant real-world events require changes to schedules and manifests; and as beds and lift become available and patients are approved for movement, tentative patient movement schedules evolve into patient movement manifests.

Deliberate Planning

Deliberate Planning supports notional planning for future operations. It allows one to develop and analyze the following long-range patient movement plans for peace and war: operations plans; contingency plans; "what if" option development; and budgetary projections. Patient requirements, lift and bed availability are based on planning factors. This mode's patient movement plans can be one of two types: requirements-based or constraint-based. Developing constraint-based plans allows one to produce a "good" but probably less than optimal plan given fixed bed and/or lift assets.

Forecasting

Forecasting supports estimating required assets (particularly lift) for two to five days into the future for actual patient movements. Based on projected bed availability, a mix of actual patient movement requirements and *advance* patient movement requirements, and possibly some notional planning factors, Global Patient Movement Requirements Center-approved patient movement schedules identify lift requirements and are passed to transportation providers. Like Deliberate Planning, this mode's patient movement schedules can be one of two types: requirements-based or constraint-based.

Reactive RePlanning

Reactive Replanning supports actual patient movements occurring now and a day or two into the future. It is based on actual bed availability, patient movement requests, and actual lift made available by transportation providers based on lift requirements passed to providers during Forecasting. Reactive Replanning functions include the following:

- Generating patient movement manifests that match patients to actual lift-beds and then publishing those manifests to the appropriate parties.

- Transmitting transportation instructions to transportation providers.

- Monitoring patient movements as they are executed and, as needed, manually intervene to complete patient movements.

Because of the high level of urgency associated with this mode, its patient movement schedules and manifests can only be constraint-based. That is, the primary goal of Reactive Replanning is to execute the best possible option given fixed bed and/or lift assets, react to changes in assets, and obtain and effectively use additional resources to accommodate unexpected emergencies.

The Impact of Occupational Cultures on Coordination of Emergency Medical Service Crew

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Summary :

The purpose of the study was to see whether one can observe different occupational cultures in the Emergency Medical Service and whether these differences in orientation among the crewmembers may have an impact on effective crew coordination. The number of crew members is usually limited to pilot, paramedic rescuer and medical doctors or registered nurse. Due to their different professional training, each crew member joins the Emergency Medical Service (EMS) with different backgrounds, interests and expectations. The operational stresses of this kind of service, however, demand team work and expose the crew's ability to coordinate their actions to work as a team. The initial study consisted of 60 operational crewmembers from the Norwegian Air Ambulance Service. They represent 65 % of the company's flying personell. Hofstede's Values Survey Module was administered for an evaluation of occupational culture. The analysis reveals group differences at the occupational level in the perception of power distribution, team orientation and achievement preferences. The results are further discussed in relation to the crewmembers' different task demands and areas of responsibility, and emphasis is put on organizational responsibility for enhancing safety and effectivity in the service.

1. Introduction

The Emergency Medical Service (EMS) flight environment is unique. The crew must respond quickly to emergency situations and often fly to unfamiliar landing sites. Time constraints, adverse weather conditions and traumatized patients call for quick decisions and high - leveled performance. The nature of EMS missions necessitates, therefore, effective crew coordination based on clear communication, teamwork and a drive to succeed.

The Norwegian Air Ambulance Service operates with crews usually limited to one pilot, one medical physician (anesthesiologist) and one paramedic rescuer. They represent three different occupations and have undergone specialized professional training prior to joining the EMS. Due to these dissimilar backgrounds and professional training one can anticipate possible problematic interaction in a number of operational areas. The theme of work and professional occupation casts new light on problems of diversity and conflict in coordinating action in a workplace. Problems addressed at the organizational level will not necessarily solve a problem that is rooted in occupational diversity. Studying the pervasive, yet somewhat unconscious effect of occupational culture upon attitudes, values and behaviour proves important. Understanding the effects of occupational culture is therefore an important prerequisite to successful EMS crew coordination and safe operations.

2. Defining occupational communities

A conception of work organized in terms of occupational communities is one of the persistent themes in sociology and has recently also been of increasing interest in social psychology. Hofstede's technical definition terms a culture as " ..the collective programming of the mind " 1980) Van Maanen and Barley (1984) define occupational communities as " .. a group of people who consider themselves to be engaged in the same sort of work; whose identity is drawn from the work; who share with one another a set of values, norms and perspectives that apply to but extend beyond work related matters; and whose social relationship meld work and leisure. " The term " ..same sort of work.." needs further elaboration. The personell working for the EMS engage in the same sort of work, the primary goal being to save lives. Based on this fact, we can argue for a common EMS culture, where the crew share the same goals, values and behaviour patterns. Numerous studies of workplaces describe the existence of diverse organizational cultures which develop as the result of the need for structure and management of uncertainties (Trice & Beyer, 1993). Cultures are a natural outgrowth of the social interaction that make up what we call organizations, and consist of shared emotional belief systems that guide our actions. An important point to keep in mind concerns the impact that shared experience will have on the formation of a common EMS culture. Working in close proximity to one another and sharing traumatic experiences, develops a teamspirit that facilitates the task of managing problems and uncertainties. This, in turn, can stimulate similar reactions and solutions. So do situations that require close coordination of activities and actions. As a

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consequence development of a common EMS culture is able to emerge. However, it is commonly known that if subgroups in the organization differ in views or if there is no agreement among individuals on appropriate management and behavioural strategies, these subgroups are unlikely to function as a team (Helmreich & Schaefer, 1993).

Why do we argue for yet another level of the culture dimension - the professional culture ? A practical way of reconciling this viewpoint, is to look at organizations as composed of a multiplicity of subcultures that are held together by a joint culture. Subcultures, according to Trice and Beyer (1993), are espesially common in societies which emphasize individualism, democracy and freedom of cherished values. Addressing the occurence of occupational cultures in the EMS may seem far - fetched and irrelevant to the general observer. However, several factors may contribute to a somewhat different view of the situation.

3. Occupational cultures in the Emergency Medical Service

The EMS consists of personnel selected on the basis of qualities such as a high sense of responsibility, the ability to make quick decisions, improvise and work well under pressure. In addition the crew members must be able to coordinate their actions in order to work as a unified team. Teamwork is essential in an occupation that may cause crew members to encounter situations that demand quick decisions and immediate action. Time constraints are frequent on many assignments and require that crews coordinate their individual responsibilities in order to save lives.

a. Individual factors

In vocations that require interpersonal interaction and team performance to ensure success, personality factors function as critical determinants of the group processes. Previous studies suggest that distinctive personality factors are important in determining choice of profession such as emergency medicine and aviation (Cassell, 1987; Litt, 1991; Fry & Reinhardt, 1969; Chidester et al, 1991).
Medical students receive intensive and lengthy socialization into beliefs, values, norms and practices. This often results in internalization of specific sets of expectations for their behaviour in future work roles. Several studies have been conducted to understand the role of the anesthesiologist. A central part of medical school curriculum includes initiation into a new identity and role - the role of the professional insider, a role which encompasses more than mastering medical knowledge and techniques (Litt, 1991). Personality profiles emphasize high scores in intellectual concerns, management potential and self-actualization, but low scores in femininity and interpersonal orientation. Task demands include manifesting decisiveness, assertiveness and self - control. Emergencies are frequent, unexpected findings must be anticipatedand and resolved immediately.

Pilot selection procedures, both civilian and military, are aimed at finding candidates with the qualities that will suit the special environment in which they are going to operate. Although the desired qualities have been modified to suit the changing aviation environment and task demands, pilots score high on intellectualization, skill and competence, courage and individualism. Pilot training is adjusted to conform to the various task demands and crew concepts. Fighter pilots are trained to work individually and rely heavily on their own competence, courage and skill. Multi - crew aircraft personnel, on the other hand, are encouraged to display interpersonal qualities. Helicopter pilots, although often working in a multi-crew concept, must display qualities of self - reliance, adventurousness, courage and precision due to the flexible, yet vulnerable character of the helicopter as a transportation device.

The paramedic rescuer has either work experience in fire-departments, general ambulance services or a degree as a registered nurse. He is often selected for the EMS due to skills in deep - sea diving and mountain-climbing. Paramedic rescuers score high in personal achievement, self-actualization and sociability, and are often termed sensation seekers (Fonne, 1993). The job as paramedic rescuer involves assisting the physician in patient treatment. He has primary responsibility for initial rescueing , i.e. tasks involving high risk activities. In some EMS crew concepts the rescuers also assist the pilot. The paramedic rescuer is therefore often termed as " the potato in the system ". Previous studies indicate a sociable individual, who is concerned about interpersonal interaction.

Ironically, the main finding from previous studies indicates that crew members display high scores on self - actualizing traits, which is a dimension not commonly recognized for its ability to promote coordinated action and teamwork.

b. Dissimilar shift - cycle

Operationally the crew work a schedule of one week of duty followed by two weeks off duty. However, this is true only to a certain extent. Due to the fact that the doctor's primary responsibility is to the hospital close to the base, he may work a different shift cycle than the other two crew members. The pilot and paramedic rescuer must therefore relate to several doctors during one period of duty. It is a well known fact that dissimilar work schedules poses a potential problem for effective crew coordination. Previous studies show differences in team performance when comparing different crew - shift cycle constellations.

4. Dimensions of culture

The present study is based on the most cited work in cross-cultural psychology, carried out by Hofstede (1980). Although the dimensions were originally chosen to discriminate among national cultures, later studies show similar findings for occupational communities. In his study Hofstede was able to identify four dimensions of cultural variation :

Uncertainty Avoidance differentiates between toleration of ambiguity and flexibility versus a preference for rules and set procedures.
The *Masculinity -Femininity* dimension indicates whether public recognition, high earnings and advancement in job is valued rather than employment security, good working conditions and relationships with peers and superiors.
Power Distance refers to the extent to which the culture accepts unequally distributed power and deals with perceptions of the superior's style of decision - making and of colleagues' fear to disagree with superior.
The *Individualism - Collectivism* dimension unfolds the extent to which the individual's behaviour is influenced and defined by others in an organization and affects the member's reasons for complying with organizational requirements.

Of particular interest in the EMS environment are the dimensions Power Distance and Individualism - Collectivism. In low - power distance crew - environments the crew members feel free to interact with one another, to offer suggestions and be consulted on matters of coordinating action. In high - power distance crews, decisions are often made autocratically. Asking for input is considered weak and incompetent. Individualistically oriented crew members value self - sufficiency and working for themselves. The overall goal of these crew members is to achieve recognition for effort. Even while working together as a team, personal reward is valued.
Statistical analysis of the data in the Hofstede study, gives no indication of correlation between two of the dimensions and occupation. According to that study calculations of *Uncertainty Avoidance Index* values at the occupational level make no sense. As for the *Individualism - Collectivism Index*, no correlations were found, although for this dimension a factor which corresponds fairly well with an " intrinsic-extrinsic " dichotomy introduced by Herzberg was found. Due to these findings, the current work will include the two dimensions found relevant at the occupational level and will focus on their impact on the level and nature of communication, leadership, coordination and conflict resolution.

Further research at the occupational level is justified by the fact that the air ambulance service consists of crew members who differ in several respects. Each crew member joins the service with different backgrounds, interests and expectations, and they are even selected partly on the basis of their individual qualities. Operationally they often have different task demands, separate work-schedules and training. The problem arises, however, how how to effectively make the most of these qualities for the purpose of coordinating group activities and enhancing safe operations.
A word of caution should be added however in the study of cultural variation, with respect to the difference between dimensions of cultures and individual variation. Leung and Bond (1989) suggested that a sharp distinction should be made between analysis at the individual level and the level of culture, and warn of any attempt at comparing the two levels of analysis. Hofstede (1980) claims that, although individual personality provides for a wide range of alternative behaviours within the same collective culture, it is nevertheless difficult to draw a sharp dividing line between the two. The current study will therefore treat the two levels of analysis as interconnected but recognize the distinction made between what is considered inherited (personality) and learned (culture).

5. Materials and Method

Subjects : The initial study consisted of 60 operational crew members from the Norwegian Air Ambulance Service. They represent 65 % of the company's flying personnel, distributed among helicopter pilots (n= 12), medical physicians (n= 29) and paramedic rescuers (n= 13). The company consists of a proportionally larger amount of medical physicians which will explain the larger sample of this particular group in the study.

Instrument : The Value Survey Module (VSM - 82), developed by Geert Hofstede, was administered for an evaluation of occupational culture. The survey module is a pencil - and -paper questionnaire consisting of 50 items aimed at collecting information on the four types of dimensions. Part 1 consists of statements reflecting work related goals. Each statement is followed by a categorized Likert scale ranging from " Of utmost importance " to " Of no importance ". Part 2 contains questions on employee values ranging from " Agree strongly " to " Disagree strongly ".

6. Results

The results from the study indicate a cultural difference on Hofstede's anthropological dimensions relevant for occupational analysis. Table 1 shows the computation of the two dimensions based on formulas developed by Hofstede (1980).

	PDI	MAS
Pilot	**45**	**16**
Doctor	**5**	**-27**
Paramedic	**40**	**-11**
Norway (Hofstede, 1980)	**31**	**10**

Tab. 1 Scores on the two dimensions for the three occupations. Scores are based on computation of formulas developed by Hofstede (1980).

Responses on the Power Distance Index (PDI) indicate differences in perception of the superior's style of decision making and of colleagues' fear to disagree with superiors. As Table 1 illustrates, pilots and paramedic rescuers show higher scores than the doctors on the power distance dimension and also score higher compared to national scores found in earlier studies (Hofstede, 1980). The results indicate a tendency for pilots and paramedic rescuers to view *moderate* inequality in power as appropriate, and accept a certain hierarchical structure in the organization. As for the doctors, the results indicate a preference for low - power distance, i.e. a flat command structure where equality among superior and subordinate is essential.These differences are statistically significant at 0.05 level. The results on the Masculinity dimension also show differences across professions (Table 1). The pilot's relatively higher preference for masculine qualities compared to doctor and paramedic, is consistent with previous findings indicating a profession which values public recognition and high earnings rather than employment security, good working conditions and relationships with peers and superiors.

a. The Power Distance Index

Questions addressing power distance include items dealing with perceptions of current situations at work and questions dealing with perceptions of the desired in the work place. Figure 1. illustrates perceptions of the participant's current situation, reflecting attitudes to organizational practices.

" How often would you say your immediate manager insists that rules and procedures are followed ? "

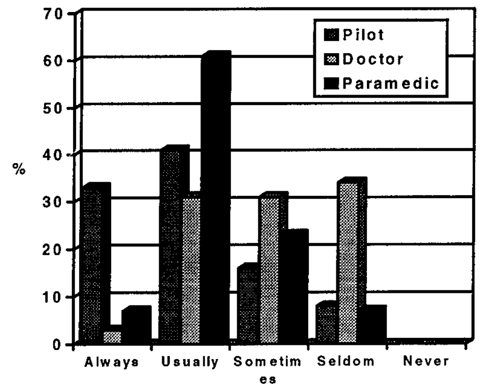

Fig. 1 .Item representing the Power Distance Index. T -test : Two sample assuming unequal variances, t (Pilot vs. Doctor) < *0.05*, t (Doctor vs. Paramedic) < *0.01.*

The results show a difference in response among the professions, differentiating between pilot and paramedic rescuer on one side who show a concern for rules and procedures and doctors who show less concern for these matters on the other. These differences are statistically significant ($p < 0.01$) and strengthen the theory of expected professional diversity concerning organizational practices.

b. The Masculinity - Femininity Index

Although most commonly known for its sex role connotation, the Masculinity - Femininity dichotomy also has implications on the social dimension. Studies have identified societies which value masculine qualities (Japan, Italy) and those which value feminine qualities (Norway, Sweden) thereby extending the utility of the dichotomy to other areas than the gender related. Occupations are shown to differ along a " social - ego " dimension of work goals, opposing the interpersonal relations goals of cooperation and friendly atmosphere (social) to assertiveness interests such as earnings and public recognition
(ego). In a vocation such as the EMS, the main objective being of humanistic and interpersonal character, one would intuitively expect feminine work values to dominate. The data in Table 1 support this notion to a certain degree. Both anesthesiologist and paramedic rescuer score high on the Femininity pole of the dimension, lending support to an interpersonal relations work environment. However, as the data illustrate, pilots show different tendencies. Figure 2. shows the distribution of responses to a question of interpersonal character - the opportunity for helping other people.

" Have an opportunity for helping other people "

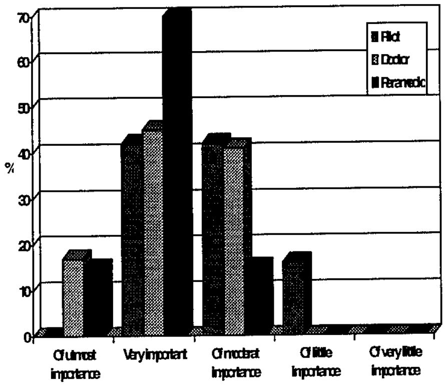

Fig. 2 Item representing the Masculinity Index.
T-test : Two sample assuming unequal variances, t(Pilot vs. Doctor) <0.05, t(Pilot vs. Paramedic) <0.01.

As mentioned above, pilots do not show interpersonal qualities to the same extent and there is a signifiant difference in their scores on several of the items representing this dimension.

7. Discussion

The analysis revealed group differences at the occupational level in the perception of power distribution, team orientation and achievement preferences. The pilots and paramedic rescuers show significantly different values on the perception of power distance than do anesthesiologists, indicating a discrepancy in attitudes to desired command structure in the service. Pilots and paramedics seem to value an aspect of structure in the company that underlines the importance of rules and regulations for safe operations.

The anesthesiologist's responses reflect values that allow for a certain degree of ambiguity and flexibility in their work, and indicate an acceptance to improvize during assignments. Considering the aspect of leadership, the results indicate task - dependent attitudes. The pilots' higher score on power distance may seem to reflect their military background, which necessarily involve relating to authority persons. In order to explaine the paramedic rescuers' preference for unevenly distributed power necessitates a closer look at their specific role in the EMS. Assisting either the anesthesiologist in patient treatment or assisting the pilot in navigating, the paramedic rescuer is also accustomed to dealing with authority and is used to taking orders. By viewing the occupations according to their role expectations and task demands, differences in perception of power distance prove functional and necessary for effective team coordination.

The analysis also revealed group differences at the occupational level in the perception of interpersonal orientation, illustrating the Masculinity - Femininity dimension. Although different, the results are not surprising, and seem to reflect the different professions' task demands as well. Due to pilots' specific task of transporting medical crew to accident sites, the opportunity of helping other people becomes secondary. On the other hand, both the anesthesiologist and the paramedic rescuer necessarily value the aspect of helping other people, seeing as this is their primary concern in the service. Figure 4 illustrates this point, lending further support to task specific attitudes among the professions.

How will the existence of different occupational cultures influence coordination of action ?

Although they show seemingly diverse values, the responses make sense if one considers the task demands divided among the crew members. The pilot's background in aviation taught him the importance of adhering to formal rules and regulations for safety reasons. Standard operating procedures (SOP) are as much a part of flying as stick-and-rudder skills and today's accident reports state that violations of SOP's are a major cause of aircraft mishaps. The job of a paramedic rescuer involves meeting challenges on a daily basis, and at times, performing dangerous rescue operations to save lives. Rules and regulations might function as security buffers, giving him certain conditions within which he can operate. Due to his function as navigator to the pilot, his background is parallel to the pilot's as far as SOP 's are concerned, explaining their similar values on this matter.

The anesthesiologist is used to work environments that accept toleration of ambiguity and flexibility. Where as they are inclined to take shortcuts, make unorthodox decisions or allow for an element of uncertainty to rule in order to save lives, pilot and rescuer feel bound by authorized procedures and are not willing to set rules and regulations aside in an emergency. Due to different task demands and areas of responsibility, these somewhat diverging attitudes do not seem to pose a problem to effective coordination of action. The pilot's main responsibility which is flying the aircraft to the accident site, implies abiding strictly to standard operating procedures, imposed on him by regulatory authorities. In this phase of the operation the pilot is in command. The results from the present study may indicate that the anesthesiologist accepts the pilot being in charge during this phase of the operation and thus the responsibility for sticking to rules and regulations, thereby respecting the pilot's limits for operating. The anesthesiologist's primary concern is to reach the patient in time and initiate treatment, therefore a different approach may be followed in this phase of the operation allowing a greater degree of freedom to improvise and make unorthodox decisions.

Respecting other crew members areas of responsibility reflects good Crew Resource Management (CRM) principles. Although coming from cultures with different

practices and values, crews who work effectively together show an ability to adapt to and respect other crew members' areas of responsibility, thereby avoiding potential problems in crew coordination and team work. The EMS demands coordination of all available resources to secure safety. CRM principles espouse a somewhat flattened command structure with respect, and group interdependence in order to achieve optimal crew coordination. In Hofstedes terms this would indicate a combination of low power distance and high scores on femininity. According to Merritt (1993) these characteristics allow for greater cross-communication and assertiveness among crew members. These authors would like to challenge this point by arguing for effective coordination and good team work even though different work values are apparent. These work values may be of great importance to accomplish their specific task in the operation within safety margins. The challenge lies in the crew members' ability to know and respect each other's areas of responsibility, their ability to switch between different authorities during short periods of time, thereby enhancing crew coordination.

Organizational responsibility

Different task demands, work values and decision making styles pose a substantial challenge to the organization behind the EMS. By setting basic standards for operations, such as formal rules of conduct and set procedures, even individualistic characteristics may prove useful and of high value. An operational environment that demands quick decisions and where time restrictions are frequent requires operating procedures that are considered appropriate by all crew members. Accident reports describe numerous situations involving time restrictions and quick decisions were SOP's have been violated in order to save time, money and patients lives. The point in issue remains that SOP's must be appropriate for all crew members no matter what the situation at hand might be.

Arriving at a common EMS culture assume an adherence to the rules and regulations imposed on them by the organization. These must be adopted by the crew members as their own working values and accepted without question. As for the EMS crew in the current study, there seems to be evidence of different work values, but that these differences are attributed to specific task demands rather than differences in occupational orientation. Shared experience, formal rules of conduct and *clear* definitions of responsibility promote the development of a common EMS culture. A common EMS culture will in turn enhance teamwork and prove to be a positive factor in the milieu.

8. Conclusion

The current study indicates a variance in responses across the three professions in the EMS and lends support to the theory of different occupational cultures in the EMS. Significant differences were found for both Power Distance Index values and for the Masculinity - Femininity values. Despite variations in expressed values, interpretation of the data must consider the impact of the three occupations' specific operational task - demands. The crew members have different responsibilities during the assignment, posing specific demands on each of them. Although the results expose the occurence of different occupational beliefs and value - systems, it does **not** necessarily imply difficulties in cooperating as a unified team. The challenge lies partly in the hands of the mangement of the organization to implement appropriate rules and procedures for operating ; task - specific rules of conduct that will enhance safety and effectivity in the service. Nevertheless, the final responsibility remains with the crew members who have to function within given operational restrictions and to show respect for their colleagues' different areas of responsibility. Flexibility and the ability to improvise will remain a core ingredient in successful operations as long as it is performed within safety margins. Working as a team is essential for successful operations and inevitably for saving lives.

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MEDICAL EVACUATION: A TRAINING PRIORITY

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"Without proper means the Medical Department can no more take care of the wounded than the army can fight a battle without ammunition"[1]

General Jonathan Letterman, M.D.

SUMMARY

Medical evacuation is a comprehensive process which includes selecting the patients to be evacuated, determining the means of evacuation, and providing enroute medical care and intervention. The military medical community continues to stress the fact that medical evacuation is a medical process, not a logistic one.[2] The "chain of medical responsibility" is an important principle, but it does not relieve the ground maneuver commander of responsibility for the treatment and evacuation of casualties from the battlefield. Medical treatment and evacuation is a sustainment function as critical to the ground commander's success as arming, fueling, fixing, or moving. If the chain of medical responsibility is to have the proper means to succeed on the battlefield, the ground maneuver commander must establish medical evacuation as a training priority equal to the other sustainment functions.

INTRODUCTION

The conventional wisdom has been that medical units and personnel had the advantage of training their wartime tasks while performing their daily peacetime medical treatment and evacuation mission. This conventional wisdom, combined with a resource constrained environment, and increased demands for medical care were often sufficient justification for medical units to support field training exercises from garrison locations. While many individual medical skills are directly transferable to the battlefield environment, many collective tasks and unit mission essential tasks must be trained in a field environment with supported and supporting units. The individual links and echelons of medical treatment and evacuation will not fuse to form a "chain of medical responsibility" without realistic training and exercise of the system in a battlefield environment.

DISCUSSION

Medical evacuation must be an integral part of the combat service support plan and a training priority at all levels. Too often medical treatment and evacuation support for combined arms exercises are considered only in the context of "real world" support to the training forces. Limited time and resources typically cause the maneuver commander to focus his training on six of the seven battlefield operating systems (BOS); intelligence, maneuver, fire support, mobility/countermobility/ survivability, air defense, and command and control. The seventh battlefield operating system, combat service support, is usually trained to the extent "real world" sustainment functions are necessary to support the training of the other six battlefield operating systems.

"Real world" medical support to combined arms exercises usually does not provide sufficient numbers or types of patients to train soldiers, leaders, and medical units in wartime patient care and evacuation. Additionally, efficacy and responsiveness in the treatment and evacuation of "real world" casualties is never compromised or subjugated for training purposes. The resultant paradigm leading into Desert Shield/Desert Storm was a focus on "real world" medical treatment and evacuation to the exclusion of required wartime training.

The failure of maneuver commanders to take ownership of medical treatment and evacuation as a wartime mission to be trained like other sustainment functions was reinforced by a stovepipe medical model committed to control of its assets as a method of standardization and efficient allocation of resources.

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The requirement for dedicated medical evacuation assets has been a time tested principle of the United States Army Medical Department since the Civil War. Dedicated medical evacuation assets are necessary to ensure the chain of medical responsibility is responsive and continuous. However, the chain of medical responsibility is not autonomous, and cannot function independently of the maneuver commander's plan. These dedicated medical evacuation assets must be integrated into the combat service support plan and the plan must be exercised.

One of the key lessons learned from Desert Storm was the need for habitual training and support relationships in peacetime to allow a more efficient transition to war. Corps level aeromedical evacuation assets face a difficult challenge in seeking out and establishing these habitual relationships. Peacetime support taskings for "medevac standby" are no substitute for effective wartime training. It is incumbent upon these air ambulance units to be proactive, to seek out training opportunities, and to insist the ground maneuver commander recognize the total training required to support the plan.

The integration of medical treatment and evacuation into combined arms training is now well established at the National Training Center (NTC) and the Joint Readiness Training Center (JRTC). The use of opposing forces (OPFOR) and training devices such as the Multiple Integrated Laser Engagement System (MILES) allow casualties to be generated in "free play" closely approximating actual combat. The treatment and evacuation of these casualties provide maneuver units and supporting medical personnel valuable wartime training.

The challenge is to extend this battle focused training beyond the national training centers to exercise the chain of medical responsibility. If today's Army is to be a wartime ready force, the medical chain of responsibility must be used in peacetime training as in wartime. Ground and aeromedical evacuation units must deploy in conjunction with the supported combat arms unit and train their wartime missions. Realism is critical to the combat readiness of these evacuation units. Soldiers injured in a training environment using OPFOR and MILES must be evacuated by ground or air from the point of injury up through battalion, brigade, and division medical treatment facilities. It is a disservice both to the training of the maneuver unit, as well as supporting medical units to simply "magic" casualties back to the exercise. Medical evacuation units cannot be solely dedicated to "standing by" for "real world" casualties. Evacuation units must commit resources to patient play to exercise the medical chain of responsibility in a battlefield environment.

The 18th Medical Command and the 2d Infantry Division in the Republic of Korea have been forging training relationships to ensure division and corps medical assets are capable of fulfilling their wartime missions. The 18th Medical Command's Constant Vigil deployed almost 400 soldiers from 6 corps medical units in support of the 2d Infantry Division's Warsteed Exercise. The habitual training relationships established between divisional and corps support units have provided valuable insights into medical evacuation doctrine, tactics, and techniques for both supported and supporting units. Opposing force (OPFOR) and MILES generated casualties were treated and evacuated by ground and/or air through division to corps level medical facilities. This training enhanced the maneuver units' capabilities to treat and evacuate their casualties while continuing with their mission. The training enhanced both ground and air assets capabilities to synchronize the medical evacuation chain. The commitment and partnership of the 18th Medical Command and the 2d Infantry Division to providing realistic wartime training in patient treatment and evacuation will safe many lives in the event of war on the Korean peninsula.

The importance of establishing habitual training relationships between medical evacuation units and combat arms units cannot be stressed enough. NATO commands must treat medical evacuation training as equal to other sustainment functions if our medical evacuation units are to be a technically proficient, wartime ready force.

This paper represents the views of the authors and does not necessarily reflect the official opinion of either the United States Army or the United States Department of Defense.

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Flying Ambulances
The Approach of a Small Air Force to Long Distance Aeromedical Evacuation of Critically Injured Patients

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1. SUMMARY

The Danish Air Force has developed a system for Aeromedical Evacuation of injured soldiers, based on flying ambulances inside a C-130. The ambulances function as mobile intensive care units, and provide a quiet, well lit and air-conditioned environment for observation and treatment of the patients. The system has a limited capacity, but it has so far proved sufficient to support the Danish participation in the UN-peacekeeping missions in the former Yugoslavia.

A number of missions have been successfully carried out, three of them with two ambulances in the C-130. The system has the added advantage of providing door to door transport, without the need for moving the patient from ambulance to aircraft, and again from the aircraft to another ambulance on arrival in Denmark.

To increase the capacity in the future, a system using specially equipped containers to be carried in the cargo bay of a C-130 is under consideration, and 2 such containers will probably be ordered this year.

For the future AIREVAC support of a Danish battalion as part of NATO's Rapid Reaction Forces, we suggest a system based on chartered Boeing 737's or similar aircraft, and reservist personnel which should be identified and trained for the mission. The readiness of the system should be insured through planning, including contracts with airlines and personnel, training of medical personnel and procurement of stretcher support system and medical supplies.

2. BACKGROUND

Until 1990, the Royal Danish Air Force (RDAF) only had a very limited need for Aeromedical Evacuation (AIREVAC), mainly from Greenland and the Faeroe Islands. These AIREVAC are normally carried out using one of the RDAF Gulfstream G-III aircraft, which are mainly used for fishing inspection around Greenland and the Faeroe Islands. These activities are still carried out the same way.

With the involvement of the Danish Armed Forces in the UN-peacekeeping mission in the former Yugoslavia, it became obvious that we had no system to rely on for a flexible response to accidents or combat casualties from those missions. There are in excess of 1300 Danish soldiers in Croatia and Bosnia today. There is medical capability in the area, but evacuation is often necessary for final treatment in Denmark, especially if the patients end up in civilian Croatian or Bosnian hospitals.

The Boeing 737 concept, which is covered in the presentation titled Danish Aeromedical Evacuation efforts during the Gulf War (nr. 9), could become part of the future Danish contribution to the NATO Reaction Forces, but is not available in times of peace or for use in connection with UN peacekeeping missions, since it is based on chartered civilian airliners. The RDAF G-III aircraft are suitable, especially since the Danish version is equipped with a large cargo door which allows easy loading of stretcher patients, or even patients in hospital beds. However, these aircraft are normally difficult to get on a short notice for an AIREVAC mission, and they are not equipped with any countermeasures against attack. As a result we will normally only have the option to use a C-130 for AIREVAC from the former Yugoslavia.

It is our opinion that a C-130 rigged with stretchers in straps in the open cargo bay does not provide an acceptable environment for long distance aeromedical evacuation in peacetime, or from UN- or Reaction Forces missions, except as a very last resort. To fill the need for a medically acceptable evacuation environment, we have developed a concept of flying ambulances in the cargo bay of a C-130, using the ambulance to provide a suitable environment for observation and treatment of the patients.

3. DESCRIPTION OF THE SYSTEM

The ambulances used are modified VW transporter models, with an advanced synchro 4-wheel-drive, providing a very safe transport under all road conditions. It also makes the ambulance a very effective off-

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road vehicle. At present 3 such ambulances are immediately available at our squadron.

The ambulances are well equipped with monitoring equipment, and other medical equipment, including for example oxygen supply, patient respirator, intubation gear, suction device, intravenous fluids and equipment, cardiac monitor with built-in automatic blood pressure measurement and temperature measurement, pulsoximeter, cardiac defibrillator and a variety of drugs and medical tools, which can be supplemented according to patient needs.

In addition to this two of the ambulances have been modified somewhat. Power converters have been constructed to allow all equipment in the ambulance to be powered by the aircraft during flight, allowing for unlimited use of monitoring equipment, light, ventilation and other electrical devices. An air-condition system, which can operate while driving as well as on external power during flight, has been installed since it has proved difficult to maintain acceptable temperatures in the patient compartment during the warm summer months, both on the ground and in the aircraft. The ambulances have been painted white, since the UN authorities in the former Yugoslavia do not like to escort army-green vehicles.

To provide oxygen during flight one or two oxygen racks can be carried in the cargo bay, each holding four 10 liter oxygen bottles, providing enough oxygen for even very long flights, thereby allowing the internal oxygen supply in the ambulances to be saved for ground transport between aircraft and hospital.

In practice, it is possible to carry one or two ambulances in a C-130 and each ambulance can carry one or two stretchers, depending on the type and condition of the patients.

In a typical mission the C-130, carrying one or two ambulances, will land on a runway near the medical facility of origin. The ambulances then leave the aircraft and drive the remaining distance to the medical facility. Here the patients are installed in the ambulances with the necessary monitoring equipment. The ambulances then drive back to the C-130, drive on board and are connected to the aircraft's power-supply and, if necessary, to an oxygen rack. An intercom line is also connected to allow communication with the aircrew. After landing in Denmark power and external oxygen supplies are disconnected, the ambulances leave the aircraft and drive the remaining distance to the receiving hospital.

The flight can be carried out with sea-level pressure in the cabin up to flight level 180, and it is possible to minimize acceleration effects during take-off and landing by using the entire runway.

When used as described this system ensures that the patient can be transported from the medical facility of origin to the hospital where final treatment can take place in the shortest possible time and without the need to transfer the patients between vehicles. The patients are transported in a very good environment with sufficient space for patients and medical personnel and with extensive possibilities for observation and treatment of the patients. It is possible to complete an evacuation from a hospital in Croatia to a hospital in Denmark, door to door, in 4 to 5 hours, depending on the amount of ground transport.

The system has been used a number of times over the last two years, carrying a variety of patients including patients with multiple injuries and patients on respirators. Three transports have been carried out with two ambulances in the aircraft. All transports have been successfully completed without any complications.

We are quite satisfied with this system, and it has been inexpensive to establish, since it is based mainly on existing equipment.

4. THE FUTURE

The system described above has worked very well, and provides a very satisfactory solution when only a few patients have to be evacuated. However, the capacity is not sufficient, and we feel that it is necessary to develop a system which can handle a larger number of patients than the maximum of four, which can be carried in one aircraft using the ambulances.

We are considering a concept using modified 20' containers, which would be insulated, air-conditioned and equipped with oxygen, suction, other medical equipment and washing facilities. A stretcher system would be installed allowing for 9 to 12 standard NATO stretchers to be carried per container. It would be possible to carry one or two containers, or one container plus one ambulance in a C-130.

The AIREVAC containers would have to be constructed with a wide folding door in each end allowing for loading and unloading of patients. The doors should be surrounded by a sealing system to provide sound proof connection between two containers in the aircraft. Folding side doors would also have to be fitted to allow for emergency escape after a crash. The container should have built-in power converters to allow for the use of external power from the aircraft or from a ground supply. The converters should provide 220 V and 12 V for use inside the container. The containers could be installed in a C-130 in less than an hour.

At the moment it appears likely that 2 such containers will be ordered this year. We would then have closed the gap between the limited capability using ambulances in a C-130 and the large capability using one or more converted Boeing 737's.

5. AIREVAC FOR THE DANISH REACTION FORCES

Denmark has offered a battalion of 4.500 soldiers as part of the new NATO Rapid Reaction Forces. This poses a new challenge to the Danish Armed Forces, which has traditionally been prepared only to defend Danish soil and adjacent areas in case of an assault on the alliance.

The focus in the area of patient evacuation has therefore been on short distance evacuation, relying mainly on ambulances and trains, and only as an exception on military aircraft.

The concept of long distance medical evacuation is thus new to the Danish Armed Forces, and a new system will have to be developed to offer long range evacuation of a larger number of casualties, in case the battalion is committed to combat far from Denmark as part of the Reaction Forces. The system would have to provide conditions for the patients which are as good as during peacetime, since it is supposed to function in a situation where the nation is, in practice, at peace.

Such a system would have to rely on AIREVAC to offer a sufficient capacity, a peacetime level of ambition for observation and treatment, and a flexibility sufficient to meet the needs of such a mission within an acceptable time-frame.

No final decision has been made about how this problem is to be solved, or who is to solve it, but we have made the following suggestion.

Three or four Boeing 737 or similar size aircraft would have to be chartered along with the necessary cockpit crew, and this should be agreed in advance with one or more airlines in order to assure fast transfer of the aircraft if the Reaction Forces are activated.

A sufficient number of stretcher systems, monitoring equipment, respirators, defibrillators and other medical equipment should be stored to allow rapid conversion of the aircraft to the AIREVAC mission.

A sufficient number of medical aircrews should be identified mainly among the Air Force reserves to allow for continuous operation of the three to four aircraft. Each medical crew should consist of 2 Flight Surgeons, 2 Nurses and 3 Aeromedical Attendants. Six to eight crews would probably be needed.

The medical crews should be trained for the mission, including lessons in AIREVAC related medical subjects as well as practical training in the operation of the aircraft's emergency oxygen systems and exits.

The necessary personnel should be identified, and the necessary equipment acquired, to form an Aeromedical Staging Facility (ASF) at the airport of origin, capable of holding at least 40 patients, equaling the capacity of one aircraft.

Most of the personnel should be on a reservist contract, with the obligation to report on very short notice when the Reaction Forces are activated.

In our opinion it is vital that these aircraft should be under military command, and that the aircraft, cockpit crews, medical crews and medical equipment should function as an integrated system. If not, it would be difficult to employ the system in a theater of limited conflict.

Combined with the option of C-130's with ambulances or AIREVAC-containers for use in periods with small numbers of patients, such a system would meet the AIREVAC needs of any mission that the Danish Reaction Forces could be committed to. At present, no decision has been made concerning AIREVAC for the Danish Reaction Forces, but we have strong indications that the solution will be very close to what I have outlined here.

Civil Reserve Air Fleet-Aeromedical Evacuation Shipset (CRAF-AESS)

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SUMMARY
In 1985, the USAF/SG, AMC/SG, and CINCAMC agreed in time of war there would not be enough C-141s and C-9s that could be dedicated to Aeromedical Evacuation (AE). It was decided to design a kit that could re-configure Civil Reserve Air Fleet aircraft, specifically the Boeing 767, into AE aircraft to perform strategic and CONUS missions. A formal acquisition program was planned and executed by the Human Systems Program Office, Brooks AFB, TX, to design, develop, and produce the conversion kit for the Boeing 767.

Developmental and Operational Test Evaluation Flights were flown in March 1991. The FAA issued flying certificates for two configurations of the Boeing 767 conversion kit; one to carry 111 litter patients and one to carry 87 litter patients. The CRAF-AESS has three subsystems. The Patient Transport Subsystem (PTS) consists of the litter stanchions and litter support arms for up to 111 litter patients. The Medical Oxygen Subsystem (MOS) consists of six 75 liter Dewars, which supply therapeutic oxygen outlets located at each potential litter position. The Aeromedical Operations Subsystem (AOS) consists of six 35 amp electrical converters to convert aircraft power to regular hospital current for medical equipment use. Electrical outlets are located at each potential litter position. This subsystem also includes two nurse workstations and seats. The airlines signed a contract with the USAF to be a CRAF-AESS supporter. Civilian airline pilots will fly the CRAF-AESS aircraft, airline flight attendants will be in charge of emergency egress, and the Systems Program Office is currently in full production for 44 shipsets. There are 17 complete shipsets delivered to date. CRAF-AESS will expand the USAF AE capabilities during war and allows medical personnel to provide excellent medical care.

BACKGROUND
In 1985, the United States Surgeon General recognized there were not enough McDonnell Douglas DC-9 Nightingales and C-141 Starlifters to provide aeromedical evacuation in time of war. Air Force Materiel Command, Human Systems Center was directed to produce a conversion kit for the Boeing 767. The conversion kit equipped the Boeing 767 and has been designed to carry 87 or 111 litter patients.

The President of the United States of America and the Secretary of Defense has the authority to activate the Civil Reserve Air Fleet. A portion of these civilian airplanes are specifically designated for medical evacuation of casualties. The civilian airline industry then has 24 hours to turn the plane over to the military. The CRAF-AESS kit will be in storage and moved to a civilian airport for conversion. The civilian flight mechanics have 12 hours to convert the aircraft. Civilian pilots will fly the aircraft and the civilian flight attendants will be responsible for emergency egress, standard briefings and meal service. The United States Air Force will provide a basic medical crew of four flight nurses and six aeromedical evacuation technicians.

The Boeing 767 is a twin engine, wide-body aircraft, which will carry up to 111 litters. Each airline that purchases this aircraft tailors it to fit their own design in relation to the location of the galleys and the lavatories. No modification to the civilian aircraft could be made in order to install the conversion kit. Therefore, it was a challenge to design one conversion kit that would fit into specific Boeing 767-200 and 300 series aircraft.

SUBSYSTEMS
To effectively manage the CRAF-AESS contract it was divided into three subsystems. Each subsystem will be discussed separately. They are the Patient Transport Subsystem (PTS), the Medical Oxygen Subsystem (MOS) and the Aeromedical Operational Subsystem (AOS).

Patient Transport Subsystem
The PTS consists of the litter stanchions and the litter support arms. Double and single free standing litter stanchions are attached to the aircraft seat rails. The CRAF-AESS has only been approved for the 87 or 111 litter configurations. The aircraft can not be re-configured during a mission and the number of ambulatory seats vary from civilian airline to civilian airline. The number of available ambulatory seats is dependent on whether a "short" Boeing 767-200 or a "long" Boeing 767-300 model is converted.

The litter support arms attach to the litter stanchions utilizing a locking pin. The are adjustable, removable and interchangeable. Each litter arm weighs 14 pounds and has been certified to pass a nine G-crash test. A U-bolt was

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designed to fit into the litter arm and secure any type of litter that it may encounter. Each litter stanchion can accommodate three litters with the top litter being mid-chest high. There are 18 inches between each litter space. The aisles are 25 inches wide. There are 12 inches between litter stanchions and 8 inches between litter handles. Each litter arm can support 250 pounds, a single stanchion can support 750 pounds and a double stanchion 1500 pounds. These are standard dimensions and weights for movement of patients in aeromedical evacuation.

Medical Oxygen Subsystem (MOS)

The second subsystem of the CRAF-AESS is the MOS. The MOS consists of six 75 liter oxygen Dewars. These supply a total of 360,000 liters of usable gaseous oxygen. This requirement was selected to provide oxygen to 60% of the patients during 12 hours of continuous use. The Dewars are placed on cargo pallets and placed in the forward cargo hold. The MOS provides therapeutic oxygen at 50+/-5psi to each litter space. Emergency oxygen is supplied by yellow airline dixie cup masks. Masks have extended tubing to allow each mask to drop to the lowest litter tier. Additionally, there is 300psi supplied to the oxygen recharger hoses.

Aeromedical Operations Subsystem (AOS)

The final subsystem is the AOS. AOS has one or two nurses' workstations and six, 35 amp electrical converters. The nurses' workstations consist of a 24 inch by 30 inch writing surface, an adjustable light, medical record and a lockable storage area. On the aft side of the workstation are two oxygen recharger hoses and two holders for emergency walk around oxygen bottles. The electrical converters will supply approximately 200 amps of electricity to the medical conversion kit. Most electrical equipment uses 1 to 2 amps of electricity and there is an electrical outlet located at each litter space.

TRAINING

CRAF-AESS was designed so that an experienced flight nurse and aeromedical technician would be able to safely fly these missions with minimal aircraft training. The first exposure will be taught at the United States Air Force School of Aerospace medicine during their initial flight training course. This consists of a didactic and hands-on training utilizing a mock up of the Boeing 767. A training video is maintained at each squadron and required to be viewed during annual training. Also, an operational manual and crew checklists were developed. There will be at least 3 to 4 hours prior to the flight where the crew can have access to the aircraft for review.

OPERATIONAL TEST AND EVALUATION

Operational Test and Evaluation are the user's responsibility. The Human System Center act as observers, evaluators, data collectors and more importantly, as liaisons between the contractor and the user. Experienced flight crews from various squadrons and volunteers who acted at patients were selected for this test. Everyone received a pre-flight briefing. All equipment certified for use in aeromedical evacuation had to be re-certified in this aircraft for Electro Magnetic Interference (EMI) and Electro magnetic Compatibility (EMC). There were eight equipment litters and each piece of equipment was tested on the ground and again in the air. All medical care was simulated during the flight, including medical emergencies. The civilian flight attendants gave all of the flight briefings and served hot and cold meals during the flight. Everyone performed well together. There were no communication problems noted. To off-load the patients, a scissor jack cargo loader (K-loader) was designed, which would raise up to the door of the aircraft and could accommodate 24 patients at a time. Once loaded it is lowered to the ground and the patients are loaded onto a medical ambulance bus for transportation to their final destination.

CONCLUSION

CRAF-AESS is a reality and provides quality transport of casualties. This is currently in production awaiting final Food and Drug Administration (FDA) review prior to fielding. CRAF-AESS will not be used on a daily basis since it is an emergency measure, only to supplement the capability of the C-9s and the C-141s during wartime or disaster.

FIRST MEDICAL TEST OF THE UH-60Q AND EQUIPMENT FOR USE IN U.S. ARMY MEDEVAC HELICOPTERS

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SUMMARY

The U.S. Army operates helicopters worldwide, including over 500 designated for medical evacuation (MEDEVAC). Advanced avionics and a commercial medical interior have been installed in a Black Hawk helicopter, designated the UH-60Q. MEDEVAC aircraft also carry commercial medical devices that can fail from stresses of in-flight use or interfere with critical rotary-wing aircraft systems. The U.S. Army Aeromedical Research Laboratory (USAARL) performed the first flight tests evaluating the medical interior in the UH-60Q and tested commercial medical devices to determine their compatibility with MEDEVAC aircraft.

Flight tests in the UH-60Q validated the enhanced capability provided by the new avionics systems, external rescue hoist, oxygen generator, built-in suction, litter lifts, and improved crew seating. The new litter lift system provided inadequate vertical clearance and several components of the restraint hardware were not sufficiently durable.

From January 1989 to January 1994, 40 medical devices, including monitor/defibrillators, infusion pumps, vital sign monitors, ventilators, oxygen generators, and infant transport incubators, were tested under extreme conditions of temperature, humidity, altitude, and vibration (MIL-STD 810). Electromagnetic emissions and susceptibility were measured (MIL-STD 461 & 462). Thirty-two percent of the medical devices failed at least one environmental test and 92% of the devices failed to meet electromagnetic interference standards. Eighteen percent of the commercial medical devices were judged unsuitable for use in the UH-60 MEDEVAC helicopter.

Testing is critical to discover the ability of a new aircraft system or medical device to perform in the harsh rotary-wing MEDEVAC environment. Failure of a device or interference with aircraft systems can result in loss of a patient or aircrew.

1 INTRODUCTION

Over 500 U.S. Army helicopters are designated for medical evacuation tasks (MEDEVAC) during mobilization. In peacetime, many units perform medical evacuations on a daily basis. These include missions to support local disaster plans, military training operations, Military Assistance to Safety and Traffic (MAST) program, and the military health care system.

Specific shortfalls have been identified in the ability of the current UH-60 MEDEVAC aircraft to perform these missions. These include reduced patient capacity in aircraft with an internal rescue hoist, absence of built-in oxygen or suction systems, and the medical aidman can not reach all of the patients on the current carousel litter rack.

Advances in military avionics and medical transport devices from the civilian air medical transport industry provide a unique opportunity for military MEDEVAC planners. If new avionics and medical devices can be adapted from off-the-shelf technology, existing MEDEVAC aircraft may be enhanced without the delays and high cost associated with a new aircraft development program.

Modern avionics and aircraft systems, including inertial and Global Positioning (GPS) systems, weather avoidance equipment, forward-looking infrared (FLIR) imaging, and an external rescue hoist can improve significantly the ability of a MEDEVAC crew to operate on the modern battlefield and in operations other than war. They promise to get the aircraft to the pick-up site quicker, in worse weather, and with reduced pilot workload. Likewise, an enhanced medical interior improves our ability to monitor and treat a critically ill patient during transport.

However, most medical equipment is designed for use in the hospital environment and rarely designed to withstand the rigors of military medical transport. These rigors include extremes of temperature and humidity, vibration and shock, and altitude exposure. The U.S. Army has standards to define the extremes of temperature, humidity, and vibration that a medical device might be exposed to during its operational life. MIL-STD-810E "Environmental test methods and engineering guidelines,"[1] details the specific requirements for environmental testing.

Over 50 years ago, the U.S. Army discovered the ignition system of military vehicles interfered with communication receivers. This began the practice of setting standards to measure and suppress electromagnetic emissions to prevent electromagnetic interference.[2] Electromagnetic interference in aircraft comes from a variety of sources: (1) Transmitters of radio frequencies, including those on the aircraft for HF, UHF, or VHF communication and

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those on the ground for FM radio or VHF television broadcasts, (2) aircraft power line (400 Hz) electrical and magnetic fields, (3) computer and avionics timing and control circuits that generate radio frequencies of 1 MHz or higher, (4) aircraft power regulators, (5) electrical switching transients from turning on and off aircraft lights, fans, or flaps, and (6) electrostatic discharges including lighting.[3] These transients and electromagnetic waves may transfer into wiring and cause electromagnetic interference to other aircraft systems or medical equipment used in the aircraft.

Currently, US Government equipment for procurement is tested for electromagnetic compatibility in accordance with standards established by MIL-STD-461C, "Electromagnetic emission and susceptibility requirements for the control of electromagnetic interference"[4] and MIL-STD-462, "EMI characteristics, measurement of."[5]

This paper describes the UH-60Q prototype MEDEVAC aircraft, including the results of initial test flights in the aircraft. In addition, it outlines the USAARL experience with environmental and electromagnetic compatibility testing of commercial medical devices over the past 4 years. The results of these tests previously have been reported, but this paper extends those results by including more recent medical device tests.[6] These results are used by the U.S. Army to determine which medical devices are suitable for use in Army aircraft.

2 MATERIALS AND METHODS

UH-60Q Proof of Principle aircraft

The UH-60 aircraft, serial number 86-24560, is configured as the Proof of Principle aircraft. This helicopter (figure 1) is equipped with an enhanced medical interior, enhanced avionics and visual displays, and an externally-mounted rescue hoist. Specific items of the medical interior include a motorized litter lift system capable of loading 3 litters or 3 seated patients on each side of the aircraft (total capacity of 6 litters). The lift system includes integral patient lighting and a built-in medical suction system. The medical interior also includes a medical cabinet and improved crew seating. The crashworthy crew seats allow the seated individual to swivel 360 degrees and move fore/aft about 2 meters. Finally, the UH-60Q includes a molecular sieve oxygen generator. The oxygen generator uses bleed air from the aircraft engines to produce high concentration oxygen. The system is capable of producing 24 liters per minute and storing 260 liters of a gas whose oxygen concentration is greater than 94%.

The enhanced avionics and visual displays in the aircraft include multifunction displays, weather radar and stormscope, inertial and global positioning navigation systems, and a FLIR imaging system. A rescue hoist is mounted on the outside of the aircraft, above the right-side cabin door.

Medical operations in the UH-60Q were completed by trained medical aidmen performing their crew duties using simulated patients during simulated aeromedical evacuation missions. These flight tests included five mission flights which spanned approximately 20 flight hours, including 10 night hours. Information about the use of medical equipment was obtained by observing the medical aidmen on each flight and asking each medical aidman to complete a questionnaire after each flight.

Figure 1. UH-60Q Proof of Principle aircraft.

Medical equipment tests

The U.S. Army program for testing and evaluation of equipment for aeromedical operations was established at USAARL to test and evaluate medical equipment for use on MEDEVAC aircraft. First, each candidate medical device is examined to determine the manner of function including electrical safety and battery life. Next, a human factors review is completed. This includes checks of the visual displays, controls, maintainability, conductors, fasteners, test points, test equipment, fuses and circuit breakers, labels and coding, and safety of the device. In the next phase of testing, each medical device is evaluated to determine its compatibility and performance in various temperature, altitude, and humidity environments. The specific tests and methods are described in Table 1.

Table 1.
Environmental Tests and Methods*

Altitude Test	Operate device at 15,000 ft altitude equivalent for 1 hour.
High Temperature Test (Operating)	Operate device at 49° C for 2 hours.
High Temperature Test (Storage)	Store device at 63° C for 1 hour, 71° C for 4 hours, and 63° C for 1 hour.
Low Temperature Test (Operating)	Operate device at 0° C for 2 hours.
Low Temperature Test (Storage)	Store device at -46° C for 6 hours.
Vibration Test	Vibration for 1 hour in each axis with signature equivalent to helicopter seat.
Humidity Test	Operate device at 30° C, 95% relative humidity for 4 hours.

*In accordance with MIL-STD-810E.

Electromagnetic compatibility characteristics are determined by testing each medical device in a computer-controlled electromagnetically shielded test chamber. First, while the device is operated, the electromagnetic field strength around the device is measured to determine the amount of electromagnetic energy conducted and radiated by the device. Next, the medical device is exposed to conducted and radiated electromagnetic fields to see if the device will malfunction when exposed to electromagnetic energy. The minimum field strength that leads to failure of the device is recorded for each narrow frequency band in the electromagnetic spectrum.[7] The electromagnetic characteristics tests are detailed in Table 2.

Table 2.
Electromagnetic Characteristics Tests*

Radiated Emissions (RE)	Assess maximum radiated emissions from 14 kHz to 12.4 GHz.
Radiated Susceptibility (RS)	Assess tolerance to radiated electric fields from 10 kHz to 10 GHz.
Conducted Emissions (CE)	Assess maximum conducted emissions from 10 kHz to 50 MHz.
Conducted Susceptibility (CS)	Assess tolerance to conducted electrical energy from 10 kHz to 400 MHz.

*In accordance with MIL-STD-461C and MIL-STD-462.

If the medical device operates properly in laboratory testing and does not produce strong electromagnetic fields within specific frequency bands, the device is approved for limited flight tests. During flight tests, the medical device is operated by a military physician in a UH-60 Black Hawk helicopter. During these tests, each aircraft system is operated to ensure the medical device does not interfere with the system or the aircraft system interfere with the medical device.

3 RESULTS

The Proof of Principle UH-60Q aircraft is capable of performing the typical MEDEVAC missions for the U.S. Army. The aviators described significant improvements in communication and navigation capability from the avionics enhancements in the aircraft. The medical aidmen praised the enhanced litter lift system, built-in oxygen and suction systems, and improved patient access. Specific concerns included the lack of storage space for personal gear, restraint system hardware on the litter lifts that broke during use, and lack of a mechanical backup for the powered litter lifts.[8]

None of the 40 commercial medical devices evaluated at USAARL failed the electrical safety evaluation. At least one human factor deficiency was noted in 20 (50%) of the medical devices tested. The most common deficiencies were the absence of circuit breakers or the absence of illumination controls for the display.

Table 3 shows the number and percentage of medical devices that failed in environmental tests. Thirteen (32%) of the medical devices failed at least one of the environmental tests. This included four failures in the altitude chamber, nine failures in the high temperature and low temperature tests, two failures in the high humidity environment, and two devices failed after exposure to vibration.

Table 4 details the number and percentage of medical devices that failed electromagnetic characteristics tests. Thirty-eight (92%) of the medical devices failed at least one of the tests. None of the devices failed the conducted susceptibility tests and only two mechanical ventilators passed all electromagnetic characteristic tests.

Among the 40 medical devices tested over the past 3 years, seven devices (18%) were found unfit for use in U.S. Army medical evacuation helicopters. This included three IV infusion pumps, a suction pump, two monitor/defibrillators, and a blood pressure monitor.

4 DISCUSSION

The "off-the-shelf" technology demonstrated in the UH-60Q Proof of Principle aircraft provided increased mission capability for the Black Hawk MEDEVAC configuration. Of particular note for the pilots was improved situational awareness provided by multi-function displays and positional navigation systems. The FLIR system (with image magnification) improved recognition of human targets on search and rescue type missions.[9] The external rescue hoist allows additional room in the cabin for patient care and transport.

The commercial litter lift system in the custom medical interior does not provide adequate vertical clearance between litters. Mitchell and Wells[10] report that the following distances should be considered minimums for clearance between litter pole surfaces in military medical ambulance vehicles capable of carrying acutely ill, injured, or otherwise unstable patients: vertical separation = 20 inches, lateral separation = 21 inches. In the UH-60, there are only 57 inches available from the floor to the ceiling. It is unrealistic to expect any stack of 3 litters to provide 20 inches of separation for each patient, but the current litter lift does not allow maximum vertical separation between litters, given the available space.

Commercial hardware used in the litter lift restraints and medical cabinet was not sufficiently durable for military service. The plastic covers on several restraint releases and plastic drawers were broken, despite careful handling.

The experience with commercial medical equipment in the UH-60Q is typical of the USAARL experience in testing commercial medical devices. Despite a lower acquisition cost, commercial devices may not fully comply with the military standards of function and durability expected with devices designed and manufactured for military use. It is our experience that inspection alone is insufficient in determining which devices may not function properly or pose a hazard to patients and aircrew. We use standardized testing in realistic environmental and operational conditions to determine if a device functions properly and is sufficiently durable for operational use.

5 SUMMARY/CONCLUSIONS

The lives of patients and the safety of the aircraft depend on the proper operation of medical devices installed and carried into the aircraft. This includes operation in the harsh environment produced by extremes of temperature, humidity, altitude, and vibration. In addition, the sophisticated electronics of aircraft systems and individual medical devices may not be tolerant of stray electromagnetic signals. Interference can render a medical device or aircraft system unusable.

Commercial avionics and medical interior items enhance the U.S. Army MEDEVAC Black Hawk helicopter. However, the current hardware requires some refinements in the design of the litter lift system and improved durability of commercial components.

Commercial medical equipment that is not designed for military service may not be suitable in the harsh MEDEVAC environment. Our experience shows that standardized testing, in realistic environmental and operational conditions, can be used to eliminate unsuitable candidate devices.

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Table 3.
Number and percentage of medical devices failing environmental tests

Type of device	Altitude	High Temp	Low Temp	Humidity	Vibration
Infusion pump (N=7)	3 (43%)	1 (14%)	0	1 (14%)	0
Monitor/defib (N=8)	0	1 (12%)	0	1 (12%)	1 (12%)
BP monitor (N=5)	0	0	0	0	0
Suction pump (N=4)	0	0	1 (25%)	0	0
Pulse oximeter (N=3)	0	0	1 (33%)	0	0
Transport incubator (N=3)	0	2 (67%)	2 (67%)	0	0
Ventilator (N=4)	1 (25%)	1 (25%)	0	0	1 (25%)
Miscellaneous (N=6)	0	0	0	0	0

Table 4.
Number and percentage of medical devices failing electromagnetic characteristics tests

Type of device	Radiated emissions	Radiated susceptibility	Conducted emissions	Conducted susceptibility
Infusion pump (N=7)	7 (100%)	0	4 (57%)	0
Monitor/defib (N=8)	5 (62%)	4 (50%)	4 (50%)	0
BP monitor (N=5)	5 (100%)	2 (40%)	5 (100%)	0
Suction pump (N=4)	4 (100%)	1 (25%)	1 (25%)	0
Pulse oximeter (N=3)	3 (100%)	3 (100%)	2 (67%)	0
Infant transport incubator (N=3)	3 (100%)	1 (33%)	2 (67%)	0
Ventilator (N=4)	2 (50%)	0	2 (50%)	0
Miscellaneous (N=6)	5 (83%)	3 (50%)	3 (50%)	0

THE LARGE- CAPACITY RESCUE- HELICOPTER CH- 53 G

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1 Summary:

A new concept has been developed

- for handling great numbers of casualties during disasters and events entailing major damage
- for providing quick support of medical treatment facilities employed by crisis reaction forces during out- of- area operations
- for accomplishing medical evacuation and combat rescue missions

In view of current planning conducted by the German armed forces in conjunction with the crisis reaction forces this concept takes on an increased tactical significance in the context of studies concerning medical support of medical treatment facilities and also when it comes to missions related to combat rescue and medical evacuation.

During several real-time operations and numerous excercises the „large rescue helicopter CH- 53 G" concept has proved to be efficient.

2 Basic Reflections on Employment

Events involving major damage and entailing great numbers of casualties or disease victims, just as disaster situations are characterized by a disproportion between what is medically necessary and what is practically feasible, between the need of many people for help and rescue and the desire for a small number of rescue workers available at the beginning to insure the best possible aid.

It will be necessary for the doctor on emergency call sent to the scene of major damage events ro reorient his thinking events, disregarding efforts for individual medical aid to be administered in the best possible manner and, rather than that provide medical aid for great numbers of people in a quick, simple and standardized manner involving the necessity to make tough choices, in other words establish priorities as a continuous process which requires constant review strictly based on the development of the situation and to be performed in a repeated manner.

Analyses obtained from major damage events having occured in the Federal Republic of Germany in recent years have indicated that the air rescue system which is normally quite dense and intense cannot be regarded as sufficient as for its capacity when it comes to dealing with great numbers of casualties. Moreover, it has been found that aid deficiencies, when dealing with an increased number of casualties, cannot be avoided due to the fact on the one hand rescue personnel are committed in place and, on the other, stocks of medication and medical supplies are liable to become exhausted.

Similar problems may be encountered in terms of size and scope as well as quality when German armed forces are employed to administer humanitarian aid under the UN umbrella but also when confronted with low intensity and high intensity conflicts during which crisis reaction forces are employed. For us Germans this means that we need to come up with new crisis managment strategies based on the lessons learned by our allied partners and friends.

Future concepts will need to be adapted to the situation while combining a variety of stages of medical care ranging from simple stabilizing measures to qualified professional medical care as well as escorting.

The credibility of new operational options will largely depend on the quality of aero medical evacuation within the scope of combat rescue and medical evacuation.

There is no doubt that air transportation is the quickest and most sparing way for injured and wounded personnel and, when it comes to rescuing injured people under pressure of time this will be a mode of transportation most likely to succeed.

Both in a fast running battle and when confronted with other situations subject to quick changes as well as in those cases when large areas need to be monitored, it will not always be possible to install well equipped medical treatment facilities and/ or medical infrastructure covering the whole area within an adequate time frame. Even in this case transportation gains additional importance when it comes to quickly moving up medical assets to the scene. The large rescue helicopter concept which we are about to introduce to you might open up new dimensions in this context as well.

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3 Operational Concepts

By the employment of large rescue helicopters various concepts may be implemented for medical operations both in the forward area and in rear area installations:

3.1 Reinforcement in terms of equipment

The CH- 53 loading capacity permits follow-on supply of expendable items and special equipment even when lines of communication are blocked or in terrain with difficult access.

Additional loads may be taken on board as a secondary measure during interim landing stops, during the approach flight or after the medical team has been flown in

3.2 Reinforcement in terms of personnel

The provision of additional medical specialists will relieve assets employed at the emergency site of some of their workload without - at the same time - weakening medical care capabilities of local hospitals.

During operations conducted by crisis reaction forces the same approach may result in a quick establishment of priorities both in terms of quality and quantity.

3.3 Deployment of ermergency patients

Helicopter transports accompanied by a doctor on emergency call involving up to 12 litter patients, 6 of them under artificial respiration provide a quick and efficient possibility for deployment of emergency patients over long distances. Casualties may be taken either to a clinic which is relatively large and which provides efficient capabilities or they may be transported in an echeloned pattern to several clinics located farther away. This results in elimination hospitalization shortages of local clinics.

3.4 Medical evacuation to rear facilities

The same concept may be used for seriously injured patients initially needing stabilization whose injuries follow specific patterns and which are to be deployed quickly and over large areas from hospitals located in major damage event areas to adequate medical centers and special clinics (such as neuro surgery, centers for the treatment of burn).

During operations conducted by crisis reaction forces an additional possibility might be considered in view of a quick evacuation of medical treatment facilities whose capacities are overburdened.

The basis for implementing operational concepts as mentioned so far has been - as for dealing with major damage events and disasters - the development of infrastructural preconditions pertaining to coordination and deployment problems. In doing so it has been necessary to give due consideration to the specific conditions involving flight operations and to the possibilities and capabilities available at hospitals used for follow-on treatment. Based on the „bottleneck" concept as related to follow-on treatment administered at clinics appropriate medical centers and clinical centers were designated in the past for the two large helicopters available in the German armed forces.

4 Conduct of missions

The operational options just portrayed result in the following as far as executing of the missions is concerned:

For medical treatment activities in the forward area:

Phase 1 provides for the quick deployment of medical specilists plus additional medical supplies and special equipment into the major damage event area.

Thanks to the deliberate and concentrated support provided by rescue personnel in place, both in terms of personnel and equipment, medical care on the scene is being improved while medical treatment deficiencies are eliminated.

For medical treatment activities in the rear area facilities:

Possibilities for medical treatment administered in rear area facilities have already been mentioned.

5 Assets available

Next, let me introduce the CH- 53, its crew and its equipment.

5.1 Sikorsky CH- 53 G

The CH- 53 G cargo helicopter is a helicopter built under German franchise. It has a lenght of 32 m, a rotor of 22,5 m in diameter, a cruising speed of 230 km per hour and a maximum speed of 320 km per hour.

When looking at this version as large rescue helicopter its initial weight is about 13 tons. Its weight at the time of departure available for maximum utilization is about 20 tons. When it comes to designating helipads both at the accident site and at hospitals or other medical treatment facilities it should be pointed out - apart from the helipad size amounting to about 80 by 80 meters - that a problem exists regarding the down- wash at a speed of up to 200 km/h with a vertical descent. The helicopter is fully suited for instrument flying, and, when used for operations at night it can be fitted with night vision equipment in support of navigation.

5.2 Personnel

In addition to the flight crew (2 pilots and 2 on- board mechanics) the medical crew consists of 3- 4 doctors on emergency call and 3- 4 paramedics/ assistants. Those specialized personnel are recruited, in the event of the two large rescue helicopters, from personnel of the respective mission units as well as from the German

military hospital at Koblenz and Ulm which are included in the concept.

5.3 Equipment

For the emergency treatment of 12 patients which are to be transported there are 6 extended equipment sets intended for „artificial respiration and circulation therapy“ which, in addition to automatic emergency respirators, include electro cardiographic monitors and pulse oximeters. Moreover, equipment includes additional expendable items which may be handed over to rescue services employed at the ermergency site without affecting organic capabilities.
The background of this equipment status is that experience teaches us that during major damage events significant deficiencies in terms of material support will be encountered about 1 hour and 1 and a half hours after medical treatment and medical care activities have been initiated.

5.4 Stages of readiness and alerting

The two rescue helicopters are on stand- by at 30 minutes notice from sunrise to sunset. Outside this timeframe takeoff must be possible within 60 minutes.
The rescue coordination point SAR- RCC Goch provides for a centralized alerting procedure.

International Access to Aeromedical Evacuation Medical Equipment Assessment Data

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Summary

Aeromedical evacuation medical equipment development using evaluation and often times modification by the manufacturer to achieve compatibility in the airborne environment began over 25 years ago at Brooks AFB in support of Military Airlift Command's (now Air Mobility Command) medical evacuation mission. This approach was adopted because sometimes standard research and development methods were not responsive to Command requirements. In the course of those years, simple items such as securing devices to those as complicated as an Extracorporeal Membrane Oxygenation System have been extensively evaluated using a battery of tests to verify adaptability to altitude and compatibility with aircraft systems. Because technology in aircraft systems and in medical equipment has advanced, so has the importance of testing for situational compatibility. Medical devices may produce electromagnetic interference with aircraft navigation or communication systems and aircraft systems can interfere with the operation of medical devices. Results of tests conducted at Armstrong Laboratory, Brooks AFB, are published as individual detailed Technical Reports and later compiled into a comprehensive document entitled "Status Report on Medical Materiel Items Tested And Evaluated For Use In The USAF Aeromedical Evacuation System" (1). This publication was available for public release and met customer access needs of the day. However, with the advent of independent air ambulance services and increase in countries actively engaged in aeromedical evacuation, a need to better communicate results of testing emerged. Researchers at Armstrong Laboratory developed a database program for rapid dissemination of medical equipment airworthiness evaluation results and are exploring electronic delivery avenues to meet the need for worldwide accessibility.

Key Words

International access, medical equipment, airworthiness, military standards, aeromedical evacuation, MEDEVAC, electronic data delivery

Introduction

Medical devices utilized in aeromedical evacuation can be adversely affected by the airborne environment and can create electrical emissions that interfere with aircraft systems. These conditions could cause life-threatening situations to patients and to entire air crews. Analysis and evaluation of equipment in the laboratory ensures safety before it is used in live aeromedical evacuation missions. Using military standards, medical equipment is tested for operational reliability in the airborne environment and evaluated for its electrical components' compatibility with aircraft navigation and communication systems. During Operation Desert Shield/Desert Storm there was a surge in requirements for equipment assessment and a need for quick retrieval of laboratory data. During the past 25 years, over 250 pieces of equipment have been evaluated. A written report on these evaluations is available through the US National Technical Information Service, but its preparation and dissemination require time. Also information must be updated periodically. As awareness of the need for airworthy certified medical equipment has expanded to include international aeromedical evacuation users, a method of sharing these data in an efficient manner was investigated. The purpose of this paper is to identify laboratory aeromedical equipment development and testing capabilities, to present appropriate standards and specifications for equipment evaluation, and to discuss the unique program developed to provide international access to Armstrong Laboratory's test results of aeromedical evacuation equipment evaluated.

Background

An effective combination of personnel and facilities at the Armstrong Laboratory Human Systems Center provides a unique capability for the development and evaluation of equipment for use in the airborne environment. Personnel include a dedicated aeromedical evacuation equipment testing staff consisting of a chief research flight nurse, biomedical research engineer, and two aeromedical research technicians. The Armstrong Laboratory has an experienced test engineer and technician to conduct electromagnetic susceptibility and emissions studies. Other supporting professional in-house staff include physiologists, flight surgeons, electrical and mechanical engineers, pilots, and technicians. There are 10 altitude and environmental chambers capable of simulating almost any research scenario. Several human-rated chambers allow for equipment operational testing under hypobaric conditions. Decompression simulation capabilities include accurately controlled rapid decompression rates as short as 0.1 second and as high as 120,000 feet. One chamber, 14,000 cubic feet in volume, can accommodate large medical systems with multiple data acquisition equipment items or several test devices and multiple researchers at one time. Another chamber with a unique capability of providing vibration testing at altitude. Within the laboratory complex are environmental chambers routinely used for testing tolerance of medical equipment to temperature and humidity extremes and a centrifuge is available if G-tolerance testing is required. Mockup aircraft of the C-9, C-130, C-141 and the Civil Reserve Air

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Fleet, Boeing 767 provide ready access in human factor assessment before the device is actually scheduled for inflight testing.

Testing Specifications

A test plan is developed for each device using military standards and procedural specifications as required for a determination of airworthiness (2). These include:

a. *Baseline Performance Assessment*: IAW MIL-STD-1472D, (Human Engineering Design Criteria for Military Systems, Equipment, and Facilities) When the device first arrives, the Project Coordinator (PC) conducts tests to validate the device functions as advertised and expected. This assessment familiarizes evaluation personnel with operation and characteristics of the device, notes design weaknesses, and potential safety hazards relating to the aeromedical environment and human factors such as human-machine interface and potential operator error. During this phase measurements are taken that serve as a baseline for later comparison to test data (3).

b. *Electrical Safety*: IAW AFR 160-3, (Electrical Safety in Medical Treatment Facilities) checks leakage current and ground resistance (4).

c. *Electromagnetic Interference (EMI) Testing*: IAW MIL-STD-461D, (Requirements for the Control of Electromagnetic Interference, Emissions and Susceptibility) Electromagnetic interference is a primary concern on an aircraft; the safety of everyone onboard may be affected by excessive EMI. Also, the electronic device may malfunction in the presence of EMI. Because of the importance of this criterion, EMI testing is performed first following baseline and safety checks. If the device fails, the manufacturer is allowed to make changes, i.e. shielding or filtering, and testing is repeated on the revised unit. If the model is commercially manufactured for hospital use and a second, modified model is provided for aeromedical evacuation, the airworthy approved model will carry a coded serial number or be appropriately labeled (5).
Tests include:

1. Radiated Emissions
2. Radiated Susceptibility
3. Conducted Emissions
4. Conducted Susceptibility

d. *Vibration Testing*: IAW MIL-STD-810E. (Environmental Test Methods and Engineering Guidelines) Equipment is secured to the test platform as it would be on the aircraft and subjected to random and sinsoidal vibration on X, Y and Z axes. Sinusoidal test displacements range from 2/10,000ths of an inch at 500 hertz to 1/100th of an inch at 5 hertz simulating the fine tremor of smooth flying to coarse turbulence or harsh landing conditions. Testing verifies the safety and operational integrity of the medical device during an evacuation mission (6).

e. *Environmental Testing*: IAW MIL-STD-810E. Environmental testing verifies tolerance of equipment to potential extremes of temperature and humidity in both operational and storage scenarios.

1. Humidity: 94±4% relative humidity, 85°F±3.6°F (29.5°C±2°C) for four hours
2. Hot Temperature Operation: 120°F±3.6°F (49°C±2°C) for two hours
3. Cold Temperature Operation: 32°F±7.2°F (0°C±4°C) for two hours
4. Hot Temperature Storage: 140°F±3.6°F (60°C±2°C) for six hours
5. Cold Temperature Storage: -40°F±3.6°F (-40°C±2°C) for six hours

f. *Altitude*: Testing includes, as a minimum, a performance check at 10,000 feet above sea level/barometric pressure of 522.8 mmHg. Standard test protocol involves ascending the chamber at a rate of 5,000 feet per minute while stopping at increments of 2,000 feet to evaluate the equipment's operational status.

g. *Rapid Decompression*: This protocol involves ascending to 8000 feet, at a rate of 5,000 feet per minute, then decompressing to 40,000 feet in 60 seconds while observing equipment performance and potential safety hazards. The chamber is then returned to ground level and an equipment performance check is accomplished to verify its operational ability. The procedure is repeated for a 7 second and 1 second rapid decompression.

h. *Airborne Feasibility*: The medical equipment is used during an actual flight to validate laboratory findings and assess human factors during clinical operation. Continued coordination with the aircraft commander ensures that any interference in navigation or communication equipment related to the test item will be identified.

Methods

Armstrong Laboratory and the Aeromedical Research team developed a database program that provides a comprehensive report on medical devices tested. These devices are categorized and cross indexed by device type, status, manufacturer, date tested, and key words to facilitate searching among the large volume of devices. Utilizing this database in conjunction with a global multimedia interactive interface allows for international accessibility to evaluation results. With this type of program, the Aeromedical Research team is able to effectively disseminate medical device airworthiness information to the growing population of independent air ambulance services and increasing number of foreign countries involved in aeromedical evacuation, MEDEVAC. This global interface will be made possible with the use of the World Wide Web (WWW) interfaces and the Internet international network system. This system merges techniques of network information and hypertext programming to make a user-friendly and powerful global information system. The Aeromedical Research team is projecting to use the Mosaic communications freeware (software available without charge) to send and retrieve information throughout the WWW system.

There are four levels of interface with this system. The first two levels involve a direct, interactive connection: an individual can access the network by use of phone modem or a Personal Computer/Macintosh (PC/MAC) hardware network interface card. By using a mouse or typing in a number, the individual is able to follow the software through a series of menus. To retrieve desired information, simply inputting key words or other criteria searches the database. If someone does not have access to Internet/Milnet they may attain this evaluation information through a third, offline level of interface, electronic mail. By providing information directly or electronically, updates are timely and the program meets rapid retrieval information demands. The last, and least desirable, level of interface involves CD ROM distribution with periodic updates for those who require the information but have isolated systems.

Conclusions

Information on the results of airworthiness evaluation for more than 250 medical devices is available to the international aeromedical evacuation community through a published report, the "Status Report On Medical Materiel Items Tested and Evaluated For Use In The USAF Aeromedical Evacuation System." This publication is currently in revision and the information is being converted into a communications software package. This informational report can facilitate selection of medical devices and equipment for use in the NATO MEDEVAC environment. Recommend use of this informational system to improve the ability of NATO nations to rapidly respond to MEDEVAC requirements.

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A GENERIC SPECIFICATION FOR SPECIAL PURPOSE AEROMEDICAL EQUIPMENT

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1. SUMMARY
A generic specification for Special Purpose Aeromedical Equipment(SPAME) has been prepared which, if met, would largely overcome the problems faced by medical operators seeking clearance for the use of such equipment in aircraft. It is suggested that this specification might be used by NATO medical forces as a basis for future standardization and thus perhaps increased interoperability of aeromedical resources and equipment.

2. BACKGROUND
Commercially-produced medical equipment has been used on RAF Aeromed/Casevac flights in both fixed-wing aircraft and helicopters for many years. However, during the introduction of the Tristar in the air-transport role in the mid-1980s, it was recognised that none of the equipment had been specifically designed or modified for use with this aircraft. In fact, no formal clearance had been obtained for the use of such equipment on aircraft, and there was little control over what equipment was actually flown. Subsequent testing has shown that few items of equipment currently in use meet the normal electromagnetic compatibility requirements for airborne equipment. Furthermore, build standards and modification states often vary markedly between supposedly identical items of equipment. Thus each item of equipment currently has to be tested individually in a specific location on each aircraft type and is cleared under a Service Deviation for use only in that location and on the basis that it generates no apparent hazard to the aircraft.

Whilst the present system of clearances offers some limited protection to the aircraft, testing and practical experience have already shown that aircraft systems can interfere with the operation of current medical equipment. Furthermore, the expanding use of sophisticated electronic systems in both aircraft and medical equipment increases the likelihood of interference between them. There is thus a requirement for SPAME which both meets normal airworthiness requirements, and thus minimises the potential hazards to both the aircraft and patient, and which would permit a wider clearance than at present.

A committee comprising both medical and technical staff was formed in 1993 to examine the problem and to produce a generic specification for SPAME. Its findings are summarised in this paper.

3. GENERAL CONSIDERATIONS
The SPAME should be designed to full airworthiness standards for all year round world wide use on a wide range of fixed and rotary wing aircraft. During flight the SPAME should function correctly to the specified medical performance and environmental requirements.

In addition to meeting the requirements of this specification, the design and construction should comply with the requirements of Defence Standard 00-35 (Environmental Handbook for Defence Material).

4. MECHANICAL REQUIREMENTS

4.1 General Design
The equipment casing should be of sufficient strength to allow it to be restrained such that it will not break up in crash conditions. All internal parts should be assembled and secured so that they remain restrained within the casing.

Sharp corners or projections on the enclosure or doors and covers should be avoided.

The enclosure material should be effective in minimising electromagnetic emissions from internal electronic circuits.

4.2 Physical Characteristics
Rotary controls should be fitted with knobs with a high impact strength and should be firmly secured to the control shaft.

Controls should be designed such that the setting should not be accidentally changed when the equipment is subjected to the proposed specified conditions for use.

The function of each control should be identified.

5. ELECTRICAL REQUIREMENTS

5.1 General Considerations
The SPAME should be designed and constructed such that electrical safety requirements are met both for the operator and the aircraft.

Each electrically powered equipment should be fitted with a single power on/off switch in the appropriate power line. There should be an indication that the power supply is switched on.

The electrical/electronic design of the equipment should be such that EMI effects are minimised.

Paper presented at the Aerospace Medical Panel Symposium on "Recent Issues and Advances in Aeromedical Evacuation (MEDEVAC)" held in Athens, Greece, from 3rd to 7th October 1994.

5.2 Power Sources

5.2.1 *External power*
All SPAME requiring external power supplies should be capable of being powered from the following:

240 V, 50 Hz 1ϕ connection to domestic supplies	
+24 to +28 V dc	aircraft supply
+ 12 V dc	vehicle supply

Aircraft supply sockets for SPAME have been rated at 10 amperes.

Environmental and electromagnetic tests should be carried out with the SPAME operating from simulated aircraft dc supplies.

Provision should be incorporated to protect electrical and electronic circuits from the inadvertent connection of dc power supplies with the incorrect polarity and to prevent interference with aircraft systems.

5.2.2 *Battery power*
All SPAME should have an internal battery compatible with use on aircraft to provide automatic battery powered operation in the event of an external power failure. Switch over to the auxiliary power should be signalled. Low battery charge should be signalled 1 hour before failure and failure also should be signalled. The batteries should have sufficient capacity to provide the capability of full specification operation for the maximum flight duration time (12 hrs) in addition to the loading and unloading time.

Where equipment is designed to be battery powered and portable, the internal batteries should be small enough to be readily transported and exchanged when necessary.

5.2.3 *Audible alarms*
Electrical failure of SPAME should produce an audible signal up to a variable sound level of 110 dBA.

Audible signals should not be the only warning of malfunction. Where equipment is in modular form and grouped together, in a host equipment, for example, all the individual audio signals should be routed to a common outlet to limit both confusion and noise.

5.2.4 *Visual alarms*
All indications of normal function should be displayed in green. Abnormal function and alarm indications should be displayed in red.

5.2.5 *Data interfaces*
The SPAME should be fitted with, or provision made for, a data interface for automatic data collection.

6. TECHNICAL REQUIREMENTS OF MEDICAL OPERATORS

6.1 General Requirements
SPAME should meet the requirements stated in the Annexes to the Specification document and should conform to IEC and British Standards appropriate to the particular equipment .

6.2 Off-the-shelf equipment
For off-the-shelf equipment, evidence of its selection for high reliability will be required. This should include any available data from previously conducted growth programmes, demonstrations and in-service data from other users, together with full justification for the relevance of this data to SPAME. This should be extended to control of parts and components, such that evidence of their selection for high reliability should be provided.

6.3 Configuration control
The configuration of components and systems for SPAME should be strictly controlled. Each type of equipment should have an agreed build standard which should be adhered to for all items, including any spares.

6.4 Electro-Physical Requirements
The electro-physical performance requirements for the following items are stated in the full Specification:

- Neonatal Equipment
- Adult Ventilator
- Oximeter
- Syringe/Volumetric Pump
- Non/Invasive Blood Pressure Monitor
- ECG/Defibrillator/Pacemaker
- End-Tidal CO2 Monitor
- Peripheral Nerve Stimulator

7. ENVIRONMENTAL REQUIREMENTS

7.1 Operating Temperature Range
The SPAME should meet the specified medical performance requirements when operated at temperatures in the range -15 °C to +50 °C

7.2 Relative Humidity
The SPAME should suffer no deterioration of performance when subjected to an atmosphere where the temperature is cycled. The relative humidity for these tests is 95%.

7.3 Altitude/Pressure
The SPAME should suffer no deterioration of performance at altitudes up to 10,000 ft or equivalent pressure (70 kPa).

7.4 Depressurisation
The Specification details a test procedure for depressurisation up to a simulated altitude of 20,000 ft, during which the SPAME should continue to function to its stated performance level.

7.5 Explosive Decompression

The SPAME should still function following explosive decompression equivalent to an altitude of 40,000 ft and without affecting aircraft operation. SPAME should be capable of correct operation following descent to a safe altitude of 10,000 ft.

7.6 Vibration

SPAME will be used in the main fuselage area of fixed and rotary wing aircraft. It should be capable of operating in the following acceleration spectral density (ASD) levels:

ASD level of 0.02 g2/Hz

over the frequency range 10Hz to 500Hz reducing ±6 dB per octave 500Hz to 2000Hz

7.7 Acceleration (Crash Conditions)

Where equipment is mounted or restrained in position, the harnesses, attachments and any back up structure should have the same standard of strength as the aircraft and should allow the following maximum accelerations without disintegration of component parts or fittings:

Forward direction : -9 (gn)

Other directions : +6 (gn)

The equipment may cease to function during and after application of the acceleration load.

7.8 Salt Mist

The SPAME should be subjected to salt mist spray appropriate for cabin equipment or instrumentation and should not be adversely affected by such spray or its resultant effects.

7.9 Water-Proofness

Electrical and electronic components and modules should be mounted in cases sealed against the ingress of water by spray or seepage.

7.10 Sand and Dust Proofing

Provision should be made to exclude sand and dust from working parts.

7.11 Shock, Drop and Topple Survivability

The equipment should survive and should be capable of fully functioning after half sine shocks of 30 g in each mutually perpendicular direction.

Each equipment should survive and should be capable of functioning after being dropped onto its base face and also onto a corner.

8. ELECTROMAGNETIC COMPATIBILITY

Requirements for electromagnetic compatibility and emitted and conducted radiation are stated in the appropriate DEF-STAN documents whose numbers are listed in the Specification.

The electrically powered SPAME should not be affected by an electric radiated field susceptibility environment of 10V/m in the frequency range 2 MHz to 1 Ghz.

The SPAME should be protected against the effects of static electricity.

9. COMPATIBILITY AND STANDARDISATION

Where appropriate, all SPAME should be compatible with Aeromedical Role Equipment and General Patient Support Equipment in current use.

10. REQUIREMENTS OF AIRCRAFT DESIGN AND TECHNICAL AUTHORITIES

10.1 Electrical Interfaces

Power supply cables for the SPAME should be fitted at the aircraft power supply interfacing end with connectors which are compatible with the connectors in the aircraft. The power cable should be of the twin screened flexible armoured SY type.

SPAME dc external power connectors should be socket type "F".

10.2 Mechanical Interfaces

All equipment is required to be restrained to prevent damage or injury in the event of adverse aircraft operation or manoeuvres. Mechanical interfacing of the SPAME with the aircraft is dependent on the aircraft type and the size and weight of the individual equipment.

11. MAINTENANCE AND CONFIGURATION CONTROL REQUIREMENTS

The Specification details the level of maintenance currently performed by RAF technicians and comments on post-design configuration control.

12. APPLICABILITY OF STANDARDS

12.1 UK/International Standards

A number of applicable UK Defence Standards have been identified in the Specification along with a small number of British and International Standards. They are listed below:

Number	Title
DEF STAN 00-1	Climatic environmental conditions affecting the design of material for use by NATO forces in a ground role.
DEF STAN 00-13	Guide to the achievement of testability in electronic and applied equipment
DEF STAN 00-18	Discrete signal interfaces
DEF STAN 00-35	Environmental handbook for defence material.
DEF STAN 00-5	Design criteria for reliability, maintainability and maintenance of land service material
DEF STAN 00-970	Design requirements for service aircraft
DEF STAN 07-55	Environmental testing of service material.
DEF STAN 16-1	Breathing oxygen characteristics, supply pressure and hoses for aircraft systems.
DEF STAN 23-51	Ambulances, military medical requirements.
DEF STAN 59-41	EMC Technical requirements test methods and limits
DEF STAN 61-3	Battery dry
DEF STAN 61-9	Specifications for battery rechargeable
DEF STAN 61-17	Requirements for the selection of batteries for service equipment
DEF STAN 65-10	Basic measurements for electronic surveillance of patients in the field.
DEF STAN 65-13	Basic voltage and current characteristics of electro- medical equipment
DEF STAN 65-31	Basic requirements and tests for proprietary electronic and electrical test equipment
STANAG 2905	Basic voltage and current characteristics of electro- medical equipment
BS 2G 239	Specification for primary active lithium batteries for use in aircraft
BS 3G 100	General requirements for equipment for use on aircraft
BS 2011	Environmental testing.
BS 5724	Medical electrical equipment.
IEC 513	Basic aspects of the safety philosophy of electrical equipment used in medical practice
IEC 601	Medical electrical equipment.
ISO 10079/1	Medical suction equipment-electrically powered suction equipment-safety requirements
RTCA DO 160C	Section 4 to 14 Environmental conditions and test procedures for airborne equipment

12.2 International Civil Aviation Organisation
The 1991-1992 Edition of the International Civil Aviation Organisation's Technical Instructions for the Safe Transport of Dangerous Goods by Air contains a new provision which states that the Instructions do not apply to the carriage of dangerous goods which are being carried to provide, during flight, medical aid to a patient. Such goods may also be carried on a flight being undertaken to collect a person or after delivering him when it is not practicable to load or unload the goods at the time of the flight on which the person is being carried.

12.3 Civil Aviation Authority (CAA)
In the UK, medical equipment is carried on board fixed and rotary wing aircraft as part of a major or minor modification to the aircraft and as approved by the Civil Aviation Authority (CAA). For this formal approval to be granted the CAA require that the equipment is designed, manufactured and tested by an organisation formally approved by the CAA. The Authority has agreed with aeromedical operators to accept carriage and use of medical equipment on board UK registered aircraft on a *demonstrated no hazard basis*. Thus it cannot be claimed that the medical equipment is approved by the CAA. The basis of clearance is one that pays regard only to the protection of the aircraft and its passengers, not one that examines the ability of the equipment to operate in the aeromedical environment.

12.4 FAA
Regulations imposed by the FAA are similar to the regulations imposed by the CAA and JAA.

12.5 ICAO
There are no ICAO regulations concerning aeromedical flights. There is, however, a Technical Instruction for the Safe Transport of Dangerous Goods by Air - this instruction is similar to the restrictions imposed by the CAA.

13. AEROMEDICAL EQUIPMENT USED BY EUROPEAN OPERATORS

An annex to the Generic Specification document lists the aeromedical equipment used by UK and European civil operators. This equipment is mainly installed or used on helicopters and clearance to fly is again determined on a no-hazard flight trial basis. The specifications for this equipment indicate an increasing awareness of environmental conditions to which the equipment may be subjected. These conditions include altitude, temperature and humidity but vibration and EMC characteristics are generally not addressed.

14. AEROMEDICAL EQUIPMENT USED BY US OPERATORS

The USAF School of Aerospace Medicine has issued status reports on the evaluation of medical equipment for use in the USAF Aeromedical Evacuation System. The equipment evaluated and found to be suitable for use on aircraft are listed in an annex to th Specification. Further examination and discussion of their test doctrines and procedures would be beneficial.

15. GENERIC SPECIFICATION COMMITTEE REPORT

15.1 Findings:

15.1.1 Current in-service equipment is not suitable for modification.

15.1.2 Estimates received from manufacturers to modify their latest equipment to the Specification increased the base price from 10 to 20 times.

15.1.3 The cost of an entirely new design and build to the Specification would be enormous.

15.2 Recommendations:

15.2.1 The cost implications may be imprecise since most manufacturers are unfamiliar with many of the implications of the Specification. The main environmental and EMC tests relating to aircraft safety should be performed on currently available medical equipment that meets the medical performance characteristics of the Generic Specification.

15.2.2 These tests, together with the modification requirements thus generated, will enable manufacturers to provide a better estimation of production costs. It may also be possible to estimate the degree of non-conformity to the Specification and the acceptability of any deviation.

15.2.3 As a large proportion of current equipment is of US origin, closer liaison with US military and civilian users and manufacturers would be beneficial.

16. NATO STANDARDIZATION

This AGARD/AMP symposium was called to address known deficiencies in NATO Medevac systems. If interoperability is a goal then standardization of SPAME will be necessary. The Generic Specification proposed for equipment for use in RAF aeromedical operations could be a basis for discussion regarding co-ordination of design and procurement.

Note:

The Generic Specification document can be freely obtained from

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AEROMEDICAL IMPACT OF THE TRANSPORTABLE PRESSURE VENTILATOR IN WARTIME AEROMEDICAL EVACUATION

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1. INTRODUCTION

Mechanical ventilation permits the early air transport of patients in respiratory failure. Ventilator-dependent patients have been successfully air transported since the 1970's in the United States Air Force (U.S.A.F.) peacetime aeromedical evacuation system[1]. The selection of suitable ventilation equipment, patient management and related safety issues, such as ventilator performance characteristics during rapid decompression, have been previously reviewed[1,2,9]. During peacetime aeromedical operations, space is not usually an issue and volume ventilators are generally used. During wartime operations, the bulky volume ventilator and the 100 volt AC (VAC) at 60 Hz electrical power converter are not readily available and take up too much space to be used on the C-130 and C-141 aircraft opportunely diverted from cargo missions to perform aeromedical evacuation. Each litter station in these cargo aircraft can hold up to ten litter patients. When a volume ventilator-dependent patient requires air transport, the litter station is typically reduced to only one or two litters.

Recent conflicts such as Operations Just Cause and Desert Storm have refocused the need to provide acute care while enroute to definitive care[4,5]. The projected large numbers of litter casualties and the potential increased demand for ventilator support for biological, chemical or burn injuries during Desert Storm resulted in the distribution of the TXP ventilator to U.S.A.F. Aeromedical Staging Facilities. Use of the TXP ventilator has the potential of reclaiming the eight or nine litter positions lost during the air transport of a volume ventilator-dependent patient due to its ability to be attached to the patient's litter[3].

2. METHODS

2.1 Equipment: The pneumatically powered and controlled time-cycled TXP ventilator is a commercially available. It is compact with a diameter of 4 inches or 10.6 centimeters (cm) and length of 6.5 inches or 15.5 cm. It is rugged and lightweight with a weight of 1.5 pounds or 0.68 kilograms. The TXP system was designed by Doctor Forrest M. Bird and manufactured by Percussionaire® Corporation[6]. The TXP is approved for U.S.A.F. aeromedical evacuation use. The TXP is powered by any standard U.S.A.F. aeromedical evacuation C-9 or C-141 aircraft oxygen system, portable liquid oxygen system or pressurized oxygen cylinder capable of delivering pressurized oxygen between 20 to 50 pounds per square inch gauge pressure (PSIG). The TXP may also be powered by an approved air compressor, such as the Airdyne® Airmeter compressor Model 2000 or any pressurized air cylinder capable of delivering 1.5 cubic feet (42.48 liters) per minute at 40 PSIG. At these pressures, the ventilated patient will receive peak pressures between 15 to 135 cm of water. The TXP has superb performance characteristics with peak inspiratory flows to the venturi of 200 liters per minute (lpm) and is source gas efficient[9]. For example, the TXP will ventilate a patient with a minute ventilation of 4.8 lpm at a cost of 1.62 lpm[9]. Optional inline flow meters are available which permit more precise control of FIO_2. It was difficult to determine the actual flow in liters per minute and volume delivered to the patient by the TXP ventilator. This is a problem common to all pressure ventilators.

The small size and weight of the TXP permit it to be attached to a patient's litter while providing ventilation during ground transport or during flight. The TXP can ventilate patients from six to 375 cycles per minute while automatically reducing tidal volumes and changing the inspiration to expiration ratios from 1:5 to 1:1 at the higher frequencies. The TXP's pressure limiting feature automatically negates breath stacking. The TXP is optionally configurable from 6 to 750 cycles per minute. The TXP can deliver a range of tidal volumes [five to 1500 milliliters (ml)] while maintaining proximal airway pressures between five to 150 centimeters of water. These tidal volumes and proximal airway pressures are dependent on the operational source gas pressure. The TXP can provide continuous positive airway pressures (CPAP) or variable positive end-expiratory pressure (PEEP) between one to 15 cm of water. The TXP provides humidification of entrained ambient air using a water impregnated wick termed the "artificial nose". The TXP also is capable of providing aerosolized medication therapy or humidification which requires a compressed gas source between 10-15 lpm. When the TXP is powered by compressed medical air with regulated pressures between 20-60 PSIG, the patient receives a FIO_2 of 21%. When the TXP is powered by 100% medical oxygen and the ventilator venturi entrains ambient air, the patient receives a FIO_2 between 40% to 62%. When the TXP is powered by 100% medical oxygen and the ventilator venturi entrains 100% oxygen, the patient receives a fractional inspired oxygen (FIO_2) of 100%. The TXP can be configured as a closed rebreathing system when needed in high chemical or biological threat environments. The TXP has manual inspiration and expiration hold buttons which enable ventilation on demand. The TXP used in Saudi Arabia was issued with a 0.046 inch outlet orifice. The 0.046 inch orifice lowers the peak inspiratory pressure for each operational pressure level by 15-35 cm of water when compared to the 0.06 inch orifice.

The TXP was designed for air transport. The TXP is designed to minimize the risk of barotrauma. The air

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entrainment inlet port of the phasitron is open to ambient pressure at all times and explosive decompressions up to 9 PSIG in under one second result in immediate venting of the lung volumes to ambient pressure. The TXP will automatically compensate for changes in altitude by increasing the delivery pressure by approximately 2% for each 1,000 foot increase in altitude for the first 8,000 to 10,000 feet in accordance with existing gas laws[6].

2.2 TXP ventilator setup and operation: The TXP inspiratory time and respiratory rate is determined by a logic cell or cartridge that is switched on and off by the bleed-off from an internal adjustable ventilation needle metering valve. The patient breathing circuit is controlled by a spring loaded non-gated, sliding venturi called the "phasitron" through which inspiratory gas from the ventilator is delivered. The phasitron is the ventilator-patient interface. The phasitron venturi entrains ambient air with the gas delivered from the regulated pressure source. The FIO_2 delivered

Operating Pressure (PSIG)	Phasitron (PSIG)	Proximal airway (cm of water)
15	5.3	24
20	7.8	42
25	10.1	60
30	12.9	78
35	15.9	97
40	18.9	118
45	21.8	132
50	24.0	147

Table 1. A summary of the peak delivery pressures for the TXP ventilator.

varies inversely with the pulmonary compliance. Stiff and noncompliant lungs will reduce the amount of ambient air entrained by the ventilator venturi. This had the effect of increasing the FIO_2 and reducing the tidal volume. The practical solution to this during the short term aeromedical evacuation flight was to measure the tidal volume with the Wright spirometer. The tidal volume is a function of rate, operating pressures and regulation of flow to the phasitron. Table 1 summarizes the peak delivery pressures as measured in cm of water for the operational gas source pressures dialed in at the regulator supplied with the unit[6].

Although the TXP is fundamentally a time-cycled ventilator, the TXP has a pressure limiter in the phasitron which functions as a relief value to prevent patient barotrauma. The setting of the pressure relief valve limit is determined by the regulated gas source pressure (see Table 1 proximal airway pressure). When the pressure limit is exceeded, the phasitron is designed to vent the excess pressure to ambient.

The TXP is color coded for easy connection. The green inlet line connects to a 30 PSIG oxygen pressure source. The white line connects the ventilator to the phasitron breathing head assembly and powers the phasitron unit[6]. When the nebulizer is used, the yellow line connects the ventilator to the nebulizer. The setup and operation is uncomplicated. Select the 12:00 index on the ventilation control knob before activating the source gas. Activate the pressure source, connect the TXP to the patient and adjust the ventilatory rate as clinically required while monitoring vital signs.

2.3 Local Patient evaluation and selection criteria: All six ventilator-dependent patients entered into the aeromedical evacuation system in February and March 1991 at King Khalid Military City in Saudi Arabia were evaluated at their local medical treatment facility (MTF) by an aeromedical evacuation flight surgeon (AEFS). By providing this onsite evaluation, the AEFS identified the "unfit to fly" patient and avoided unsafe patient movements.

A clinically stable patient was capable of completing a bed-to-bed aeromedical evacuation of six to 24 hours duration with an expected low risk for incurring a complication requiring invasive treatment of intervention beyond the scope of general nursing care. Clinically stable patients generally had hemoglobin values of 10 or more grams, hematocrit of 30% or more, and respiratory rates less than 25 breaths per minute. The patients' pO_2 values, when corrected to approximate sea level values, were equal to or greater than 100 mm Hg and their oxygen saturations were above 90%. The AEFS performed a bedside TXP ventilator trial which included measurements of tidal volume, minute ventilation, peak inspiratory pressure and oxygen saturation values using a Wright spirometer and a pulse oximeter. Patients were accepted for aeromedical evacuation following a successful ventilation trial. The criteria for success were tidal volumes between 10-15 ml/kg, peak inspiratory pressures of 50 or less cm of water, arterial pO_2 when available of 100 or more mm Hg and oxygen saturations above 90%.

Expected military cargo aircraft cabin pressure altitude typically ranged between 5,000 to 9,000 feet with a median of 6,000 feet[7]. The normal individual at sea level will have a pO_2 between 80 to 95 mm Hg and at 5,280 feet will have a pO_2 between 65 to 75 mm Hg. Based on the altitude table summarized in Table 2, a baseline pO_2 of 100 mm Hg at sea level will insure proper oxygenation at a cabin altitude between 6,000 and 9,000 feet.

Altitude (feet)	Barometric Pressure (Torr)	PIO_2 (Torr)	Alveolar pO_2 (Torr)	Alveolar pCO_2 (Torr)	Oxygen Saturation (Torr)
SL	760	149	103.0	40.0	97%
5,000	632	132	76.7	37.4	
6,000	609	127	71.8	37.0	
7,000	586	122	67.0	36.4	
8,000	565	118	62.7	36.0	93%
9,000	543	113	58.1	35.4	
10,000	523	109	53.9	35.0	84%

Table 2. Summary of changes in oxygen content with increasing altitude.

The patient with a pO_2 65 mm Hg or less at sea level should receive supplemental oxygen therapy. This table is calculated by the alveolar gas equation where pAO_2 = the partial pressure of alveolar oxygen, PB = barometric pressure, pH_2O = 47 mm Hg, $pACO_2$= partial pressure of alveolar CO_2, FIO_2, PIO_2=partial pressure of inspired oxygen and R= the respiratory exchange rate which varies between 0.8 to 0.85 for a balanced diet (see equations 1 and 1a). The PAO_2 is generally equal to the partial pressure of arterial oxygen (paO_2). The $PACO_2$ is generally equal to the partial pressure of arterial carbon dioxide ($PaCO_2$).

$$pAO_2 = [(PB - pH_2O)*FIO_2] - [(PACO_2 * (FIO_2 + (1-FIO_2)/R))] \quad (1)$$

or more simply

$$pAO_2 = FIO_2 * (PB\text{-}pH_20) - (PACO_2/R) \qquad (1a)$$

2.4. Ground transportation: The local MTF physician, nurse anesthetist, respiratory technician or AEFS accompanied the patient to the aircraft. Although manual bag-valve-mask ventilation was available, the TXP was uniformly used when available to minimize the changes in pCO_2 or pH values usually seen in patients manually ventilated during transport[8]. The primary method of patient transport to the aeromedical staging facility, flight line and destination hospital at the end of the flight was the ground ambulance or ambulance bus. Helicopter transport was utilized when clinically indicated.

2.5 TXP duration times for oxygen delivery systems: The TXP ventilation duration times using various oxygen storage devices are summarized in

Storage Device	Volume (liters)	$Tank_{CF}$	Duration in Minutes (Pressure Reserve) 200 PSIG	500 PSIG
PTLOX - 10 liters	8,500	-	300	300
D oxygen cylinder	359	0.16	11- 16	9- 14
E oxygen cylinder	625	0.28	19- 28	16- 24
M oxygen cylinder	3,028	1.38	92-138	78-117
G oxygen cylinder	5,299	2.41	161-241	137-204
H oxygen cylinder	6,907	3.14	209-314	178-267

Table 3. The useful service life in minutes for various oxygen storage systems. The PTLOX values are empirically observed estimates. The duration in minutes was calculated using PIP between 20 to 30 cm of water.

Table 3. These durations apply to an idealized 70 kilogram male patient with a minute ventilation of 10 liters and assume that for each ml of oxygen delivered to the ventilator venturi, one ml of ambient air will be obligated giving an entrainment ratio of 1:1. This will produce a FIO_2 of 60%.

The useful service life durations given in Table 3 are also the result of a few assumptions. The first is that the oxygen cylinders are initially pressurized to 2,200 PSIG. The second is the oxygen cylinders will be removed from service when either 200 or 500 PSIG remain in the tank. At tank pressures of 500 or less PSIG, regulator control of the gas flow from the cylinder is inaccurate and potentially unsafe. This reserve of pressurized oxygen represents a safety margin for the patient. The third is that the useful service duration has been reduced by one half which again provides a margin of safety for the patient. As an example, each of the three TXP ventilator-dependent patients aeromedically evacuated from Saudi Arabia to Germany was successfully ventilated with a single ten liter portable LOX system. The duration calculations are derived from equations using a denominator of liters per minute. When used in this fashion, a reasonable duration of useful service can be calculated. Given the uncertainty of determining the actual flow in liters per minute, an empirical approach of substituting the peak inspiratory pressure (PIP) for the flow in lpm was adopted (equation 2). In spite of these empirical origins, the United States Army Burn Center transportation teams have used these service duration calculations with success. The success is based in large measure to the generous safety margins. The useful service duration (equation 2) is calculated using the tank correction factor ($Tank_{CF}$), the tank pressure in PSIG ($TANK_{press}$), the tank safety factor ($TANK_{SF}$) and the peak inspiratory pressure (PIP)[10]. The $TANK_{CF}$ calculation first requires the conversion from cubic feet to liters which is obtained by multiplying the cubic feet (CF) of the full cylinder by the conversion factor of

$$\text{Duration} = \frac{TANK_{CF} * (TANK_{press} - TANK_{SF})}{PIP} \qquad (2)$$

$$Tank_{CF} = \frac{\text{Liters}}{\text{PSIG of full cylinder}} \qquad (3)$$

(28.32 liters/CF). The $TANK_{CF}$ calculation (equation 3) is then calculated by dividing the liters by the PSIG of the full cylinder. The calculated and estimated useful service life duration values in Table 3 represent conservative and minimal duration values.

2.6. Aeromedical evacuation: Prior to air transportation in the C-130 or C-141, aeromedical evacuation personnel examine the patient to determine flight readiness and replace all air filled indwelling catheter cuffs with saline. During flight, the TXP ventilator is powered by the oxygen regulator panel in the C-141 and by the ten liter liquid oxygen (LOX) system in the C-130. The LOX is a portable system carried onto the C-130 by the aeromedical evacuation team for patient use. Since approximately 10% of the oxygen is lost over 24 hours in portable LOX systems, the useful volume is 7,650 liters.

The patient was continuously monitored during the flight with a pulse oximeter. Periodically during the flight, the AEFS performed a clinical assessment and altered the TXP respiratory parameters or requested endotracheal suctioning if required. When clinically indicated, tidal volumes were obtained using the Wright spirometer.

Prior to landing, the AEFS performed a clinical assessment of the patient to determine if a helicopter transport of the ventilator-dependent patient was required.

3. RESULTS

Table 4 summaries the case histories for the six ventilator-dependent patients who were air transported during Operation Desert Storm by the USAF aeromedical evacuation service. Each of these patients were evaluated by an AEFS at the local MTF and had a TXP ventilator trial performed. All six patients had successful preflight TXP ventilator trials. All six patients were successfully ventilated during flight. There were no inflight deaths. Table 4 lists the inflight morbidity for these patients. The inflight morbidity was largely due to problems with the patients handling secretions in the generally low (2 to 10%) relative humidity aircraft environment. The first three patients had significant problems with drying of secretions during flight. Patient #1 had a 3% fall in his oxygen saturation and presented with generalized tonic-clonic seizures. The 3% fall in oxygen saturation is potentially misleading in that this drop could represent a drop of 20-30 Torr in PO_2. This problem was addressed and largely resolved with inline

Patient Diagnoses		Transport Indication	Inflight Morbidity	A/C	Flight
#1	Motor vehicle accident (MVA) with head injury and coma, s/p laparotomy, s/p chest tube placement for pneumothorax	Longterm nursing care	Mucus plugging with 3% fall in oxygen saturation leading to seizures that required repositioning of endotracheal tube	C-141	8 hrs
#2	Grenade injury with gluteal and buttock injuries, treated sepsis, s/p chest tube placement for hemopneumothorax	Longterm nursing care	Mucus plugging which responded to suction	C-130	1.5 hrs
#3	MVA with multiple crush injuries, renal failure, s/p chest tube for pneumothorax	Dialysis	Mucus plugging which responded to suction hypotension given IVF's	C-130	1.5 hrs
#4	First and second degree burn injuries (35% - 40%) to face and chest from field kitchen kerosene fire	Burn center treatment	Uneventful	C-141	8.2 hrs
#5	Shrapnel head injury with coma	Longterm nursing care	Uneventful	C-130	1.5 hrs
#6	Unexploded ordinance injury with head injury and coma, with multiple shrapnel wounds	Longterm nursing care	Mucus Plugging which responded to suction	C-141	8.1 hrs

Table 4. Summaries of the six TXP ventilator-dependent patients transported by the U.S.A.F. aeromedical evacuation system.

humidification. As a result, patients #4 and #5 had uneventful flights. Patient #6 had increased secretions noted prior to the aeromedical evacuation. During the aeromedical evacuation the patient received inline humidification and minimal suctioning was required.

4. DISCUSSION

The TXP proved to be an effective and simple ventilator when used during ground and air transportation. The TXP provided a tighter control of ventilation and minimized changes in pH or pCO_2 usually seen with manual bag-valve-mask ventilation. The TXP also reduced the number of personnel required for ground transport. Connecting the TXP to operational pressure sources was straight forward due to its color-coded connection system. All patients were successfully ventilated with peak inspiratory pressure between 15 to 25 centimeters of water. The portable ten liter liquid oxygen systems on the C-130 and the oxygen panel on the C-141 provided more than adequate inflight oxygen which permitted the use of inline humidification at an acceptable cost of 10-15 lpm of pressurized oxygen. The inline humidification worked well in practice and largely resolved the problem of drying of secretions.

There were three major problems encountered in the use of the TXP. The first problem was to obtain a reliable method of determining the useful service life of the oxygen delivery systems. The calculations presented in this paper worked well in practice. The use of the Wright spirometer during flight added a means to directly measure the minute ventilation if the patient's condition changed. The second was securing proper adapters to connect the TXP to the pressurized oxygen cylinders used during transport. The ground ambulance cylinders had low pressure flow meters that were calibrated in zero to 15 lpm. The TXP requires a minimum of 30 or more lpm for proper operation. As a result, this readily available regulator was useless. Early in the course of the TXP use, manual bag-valve-mask ventilation was occasionally required when adapters for the E oxygen cylinder bottles were not available. Carrying the proper adapters during ground and air transport resolved this problem. The third was that most of the flight surgeons tasked for the aeromedical evacuation mission were not familiar or comfortable with pneumatically powered and controlled time-cycled ventilators. This lack of familiarity in education and training was corrected by inservice training.

5. SUMMARY

Carefully selected patients requiring mechanical ventilation can be safely transported on tactical or strategic aeromedical evacuation missions using the TXP ventilator. The TXP ventilator functioned well in the wartime aeromedical evacuation system in Operation Desert Storm. The TXP ventilator significantly reduced the space requirements for ventilator-dependent patients without compromising patient safety and permitted the aeromedical evacuation of an increased number of patients. Patient safety requires that AEFS and other qualified health care

providers receive training and demonstrate proficiency in the management of TXP ventilator-dependent patients.

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REQUIREMENT FOR ONBOARD TELEMETRY EQUIPMENT

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SUMMARY

The use of onboard telemetry equipment in EMS ground and air ambulances has made significant inroads in the civilian sector. This article reviews data from 661 patients evacuated by UH-60A helicopters in the Republic of Korea from June 1993 through May 1994. Patient categories, enroute care provided, and patient outcomes are analyzed to determine if onboard telemetry equipment would have improved enroute care provided or patient outcome. The data indicates onboard telemetry would have been of marginal utility and would not have affected patient outcomes. It is the conclusion of the authors that onboard telemetry equipment would be of limited value in military aeromedical evacuation operations.

INTRODUCTION

Since the days of Doctor Jonathan Letterman (US Civil War, 1861), evacuation of wounded soldiers from battle has been an integral part of military medical care. It is generally accepted that the first aeromedical evacuation occurred during the siege of Paris in 1870, when casualties were evacuated by balloon.[1] Aircraft were used for patient transport during both World Wars I and II, but the first use of aircraft to pick up and transport wounded soldiers from the battlefield was accomplished by the United States Army in Korea in 1951, and this technique was expanded and refined in Viet Nam from 1964- 1975.

The death rate for wounded in action in W.W.I for those who lived long enough to get to medical care was 8.5%; in W.W.II, 4%, Korea, 2%, and Viet Nam 1%.[2] While all improvements in the mortality rate cannot be attributed solely to air evacuation because many major advances were made in medical and surgical care, rapid transportation by air with effective medical care enroute certainly was a major factor.

Australia, a land of vast distances and scattered population, probably deserves credit for taking the lead in integrating aircraft into the health care delivery system. The first routine use of civil helicopters for medical evacuation in the United States occurred in traffic choked Houston, Texas in the late 1970s when it became apparent that rapid transport would improve survival in the "golden hour" of trauma care. Subsequently, civil aeromedical evacuation using both rotor wing and fixed wing aircraft has become routine throughout the United States.

While it is not our purpose to discuss in detail civil aeromedical evacuation operations, civil operators have utilized various types of aircraft, flight personnel, and equipment. In addition to pilots (1 or 2), both physicians and nurses have been utilized as medical attendants. Equipment on board ranges from basic devices for basic life support to extremely sophisticated devices for advanced life support activities, communications, and recently, telemetry of patient data to a ground base station. Considerable experimentation regarding the most appropriate crew and equipment has occurred and has been influenced by expense, geography, and competition within the health care industry.

Military aeromedical evacuation operations are concerned with expense also, but equally as important are considerations of (1) standardization throughout the organization, (2) centralized policy decisions, (3) personnel turnover, (4) inability to easily or rapidly make organizational changes, and (5) necessity to be prepared for combat operations.

EPIDEMIOLOGY OF AEROMEDICAL EVACUATION IN KOREA

For this report all actual aeromedevac flights in the Republic of Korea during the period June, 1993 through May 1994 were reviewed. During this time 661 patients (active duty, dependents, and retired beneficiaries) were transported. The entire flight hour program of the 377th Medical Company (Air Ambulance), which includes training and maintenance flying, was 4900 hours.

Many (39%) of the patients originated in the 2ID area (Figure 1). Patient evacuation demand is not related to time of year, but may be related to periods of training by the division (Figure 2). Consistent with US Army doctrine, most patients were initially seen and stabilized by on site medical personnel (Figure 3), then transferred to the 121st Evacuation Hospital (Figure 4). Because aircraft are prepositioned throughout the peninsula, most evacuation flights are relatively short (Figure 5), less than 30 minutes. Flights longer than 60 minutes originate from the Taegu area or further south. Most patients were acutely ill or injured (Figure 6), with local ground based medical personnel making the evacuation decision. Because of pre-evacuation assessment and stabilization, most patients did not require enroute intervention (Figure 7) except for maintenance of established treatment. The majority of enroute interventions were basic medical treatments, with very few sophisticated resuscitations. Acute trauma and orthopedic problems constituted 28% of the evacuations (Figure 8). The low rate of 11.9% for cardiovascular problems probably reflects the young age of the population supported, but this is also the

1 DeHart, R.L., ed.: Fundamentals of Aerospace Medicine. Philadelphia, PA, Lea & Febiger, 1985, p. 600.
2 Ibid., p. 601.

Paper presented at the Aerospace Medical Panel Symposium on "Recent Issues and Advances in Aeromedical Evacuation (MEDEVAC)" held in Athens, Greece, from 3rd to 7th October 1994.

population supported during any period of armed hostilities. As expected, these patients did very well during their transportation, and none subsequently died enroute or at the 121st EVAC Hospital (Figure 9).

DISCUSSION

The 377th Medical Company (Air Ambulance) is the only helicopter aeromedical evacuation unit supporting U.S. Forces in Korea. It is currently organized with 5 platoons, 25 UH-60A aircraft, and 158 personnel. During the period under review the headquarters and 1st flight platoon were located at the Seoul Military Airport with second flight platoon at Camp Humphreys and third flight platoon in Taegu. Detached elements of 2 aircraft with crews were maintained at Camp Casey in the 2nd Mechanized Infantry Division (2ID) area in the North. All operational missions originated from Camp Humphreys, Camp Casey, or Taegu.

An aeromedevac crew consists of 2 pilots, either commissioned or warrant officers who have taken specific aeromedevac training, an enlisted crew chief, and an enlisted medic. This medic has taken standard Army basic medic training, plus an additional aeromedevac course at Ft. Rucker, Alabama which includes Emergency Medical Technician (EMT) training. No crewmember is trained in Advanced Cardiac Life Support (ACLS). Equipment on board consists of a standard Army aeromedevac set, with some local augmentation. Enroute medical care is reviewed for quality assurance by a senior flight medic with flight surgeon oversight.

The basic concept of military medical care is that it is provided by echelons. To carry out the correct procedure at the appropriate time and in the appropriate facility is a rule of military medicine.[3] In this context, the US Army desires to stabilize all patients as far forward as possible and therefore transport primarily stabilized patients. Unstable patients which must be transported are only taken as far as the closest adequate treatment facility, which in peacetime may be a civilian facility.

Medical technology has become dramatically more sophisticated in the last 20 years to the point where many procedures which are technically possible are being considered medically necessary, or even a "standard of care." While this concept may be appropriate in an economically unconstrained, competitive civilian environment, in the harsher, more austere military environment it is mandatory to ask where it makes the most sense to spend money.

Telemetry of enroute patient data to a ground base station may be useful for these reasons: (1) The receiving hospital obtains real-time patient information, (2) more expert interpretation of that data may be available at the base hospital, (3) the medical team in the aircraft receives better advice regarding patient care enroute, and (4) the receiving hospital is better prepared to continue management.

However, with a broader focus, it is apparent that regardless of the sophistication of patient information, the environment of helicopter aeromedical evacuation is severely compromised by inadequate space, poor temperature control, and excessive noise and vibration. While the US Army is attempting to improve the helicopter environment with the new UH-60Q model, these limitations will remain significant factors and inherently make sophisticated enroute medical care more difficult.

Even considering the above limitations, appropriate enroute medical care can be provided to acutely ill and injured patients. After initial stabilization, established protocols provide guidance to flight crews for all common problems. Most medical conditions in both peace and wartime can be adequately treated using basic life support procedures which are readily amenable to protocols. This fact significantly reduces the advantages of telemetry. It should also be pointed out that only 11.9% of patients transported had cardiovascular diagnoses which most benefit from telemetry, and it can be anticipated that during wartime, even fewer of these patients will require evacuation.

Finally, technically sophisticated equipment requires equally sophisticated and expensive acquisition, maintenance, and life cycle considerations.

CONCLUSION

Using standard U.S. Army equipment, personnel, training, and doctrine, the 377th Medical Company (Air Ambulance) safely and efficiently transported 661 patients in the Republic of Korea from June, 1993 through May, 1994. While these patients were transported in peacetime, the same fundamentals would apply during wartime. Patient outcomes would not have been significantly altered by telemetering enroute patient data to and from the receiving hospital.

Our opinion based on our experience is that it is unnecessary and a poor utilization of scarce resources to provide telemetery monitoring of airborne patients in the military helicopter evacuation mode. Sophisticated telemetry acquisition, maintenance, and life cycle costs would unnecessarily burden the logistic system without significantly improving patient care or outcome.

This paper represents the views of the authors and does not necessarily reflect the official opinion of either the United States Army or the United States Department of Defense.

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[3] Dolev, E., and Llewellyn, C.H.: The Chain of Medical Responsibility in Battlefield Medicine. *Military Medicine*, 150:471-474, 1985.

Number of Patients by Geographic Pick Up Location	
2nd Infantry Division Area	259
Camp Humphreys	150
Seoul	27
Osan	56
Taegu	110
Kunsan	21
Pusan	12
Cheju-do	3
Other	23

Figure 1.

Requirement for Onboard Telemetry Equipment; Granger and Urbauer

Number of Patients Transported by Month	
June 93	32
July 93	53
August 93	44
September 93	61
October 93	60
November 93	37
December 93	49
January 94	65
February 94	48
March 94	72
April 94	71
May 94	69

FIGURE 2.

Number of Patients by Type of Pickup Location	
Troop Clinic	504
Military Hospital	95
Field Site	62
Civilian Hospital	0

Figure 3.

Requirement for Onboard Telemetry Equipment; Granger and Urbauer

Number of Patients by Final Destination	
121st Evacuation Hospital	653
Other Military Hospital	5
Civilian Hospital	2
Troop Medical Clinic	1

Figure 4.

Requirement for Onboard Telemetry Equipment; Granger and Urbauer

Number of Patients by Length of Flight	
Less than 30 Minutes	343
Greater than 30 Minutes	187
Greater than 60 Minutes	122
Greater than 90 Minutes	9

Figure 5.

Requirement for Onboard Telemetry Equipment; Granger and Urbauer

Number of Patients by Category/Acuity Level	
Routine	26
Priority	188
Urgent	447

Figure 6.

Requirement for Onboard Telemetry Equipment; Granger and Urbauer

Number of Patients by Type of Enroute Intervention	
Fluid Administration	74
Immobilization	44
Drugs	16
Basic Life Support (CPR)	3
Electroshock	1
Maintain Established Rx	523

Figure 7.

Requirement for Onboard Telemetry Equipment; Granger and Urbauer

Number of Patients by Diagnosis	
Cardiovascular	79
Neurologic	30
Orthopedic	51
Acute Trauma	133
Gastrointestinal	103
Pulmonary	40
Psychiatric	32
Genitourinary	93
Other (Environmental, General Medical, etc.)	100

Figure 8.

Requirement for Onboard Telemetry Equipment; Granger and Urbauer

Number of Patients by Patient Outcome	
Unchanged	655
Deteriorated	4
Improved	2
Death	0

Figure 9.

Care in the Air - A System Analysis of Clinical Outcomes in Aeromedical Evacuation

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1. SUMMARY

In 1993 a clinical outcomes study of the Continental United States (CONUS) Aeromedical Evacuation (AE) system was undertaken. Between 15 Feb and 31 Oct 93, AE patients were screened for a series of adverse clinical outcome indicators and process discrepancy indicators. Rates were determined for each of the indicators. Defense Medical Regulating Information System (DMRIS) records were reviewed to obtain patients' demographic data. Correlations between diagnoses and adverse clinical outcomes were evaluated.

During AE missions the adverse clinical outcome rate was 0.9 per 1000 patients. Unanticipated need for O2 and development of chest pain in flight accounted for 73% of the in-flight adverse outcomes and occurred primarily in cardiac patients. The process discrepancy rate was 10 per 1000 patients - 10 times the adverse outcome rate. For patients remaining over night in Aeromedical Staging Facilities the adverse outcome rate was 2.9 per 1000 patients. ENT barotrauma accounted for 66% of these patients.

The adverse clinical outcome rate for peacetime AE patients is very low. Patients with limited cardiopulmonary reserve are at higher risk during AE. During wartime and military operations other than war, AE patients are more likely to have limited cardiopulmonary reserve and be at higher risk due to injuries, malnutrition, or limited medical care prior to flight. Special attention to oxygen requirements, altitude restrictions, complete documentation of care required en route, and proper selection of medical attendants are crucial for good outcomes in AE.

2. ABBREVIATIONS

AE: Aeromedical Evacuation
AECC: Aeromedical Evacuation Coordination Center
AECM: Aeromedical Evacuation Crew Member
ASF: Aeromedical Staging Facility
CHF: Congestive Heart Failure
CONUS: Continental United States
DMRIS: Defense Medical Regulating Information System
DNR: Do Not Resuscitate
FY: Fiscal Year (from 1 Oct to 30 Sep the following year)
GPMRC: Global Patient Movement Requirements Center
O2: Oxygen
RON: Remain Overnight
USAF: United States Air Force

3. BACKGROUND

In August 1992, the Command Surgeon of the USAF Air Mobility Command (then Brigadier General Charles Roadman) declared 1993 to be the "Year of Care in the Air". Previously there had been no systematic analysis of clinical outcomes in AE patients. A team was formed from members of the Command Surgeon's office, active and reserve aeromedical evacuation (AE) squadron members, and physicians who frequently used AE. It's purpose was to study clinical outcomes in AE. The study goals were: baseline AE clinical outcomes, identify the key processes which impact those outcomes, and develop a system to continually assess, improve, and facilitate decision-making in AE. This paper focuses on the first two goals.

4. METHODS

AE patient demographics and information on patient variables were obtained from the Defense Medical Regulating Information System (DMRIS) data base. DMRIS is the system currently used to report patients for AE.

The members of the Care in the Air team used brainstorming techniques to produce the list of possible key AE processes, the study screening indicators, and patient/mission variables analyzed in this study.

The In-flight study period was 15 Feb to 31 Aug 93. Because some outcomes may not become apparent until after the flight, patients remaining overnight (RON) in Aeromedical Staging Facilities (ASFs) were studied from 1 Aug to 31 Oct 93.

During the study periods, 100% of patients were screened for the adverse outcome indicators by AE crew members (AECMs) and Aeromedical Staging Facility (ASF) personnel using a data collection form developed for the study. For each patient with an adverse outcome the AECM or ASF personnel were asked to record which AE key processes, if any, they felt contributed to the development of the outcome.

Because of the requirement for each AE squadron to run a discrepancy analysis program, a set of AE process discrepancy indicators was developed and used during the In-flight portion of the study only.

The results were analyzed to determine if there were associations between development of adverse outcomes and specific diagnoses, AE key processes and/or AE process discrepancies.

Paper presented at the Aerospace Medical Panel Symposium on "Recent Issues and Advances in Aeromedical Evacuation (MEDEVAC)" held in Athens, Greece, from 3rd to 7th October 1994.

The proportion of cardiac diagnoses in patients with adverse outcomes was compared to the proportion of cardiac diagnoses among all patients air evaced during the study period to determine if AE posed a higher risk for cardiac patients.

5. RESULTS

5.1 AE Patient Demographics

The top five medical specialty codes of AE patients in each of four AE movement categories (urgent, priority, routine inpatient, and routine outpatient) were determined.

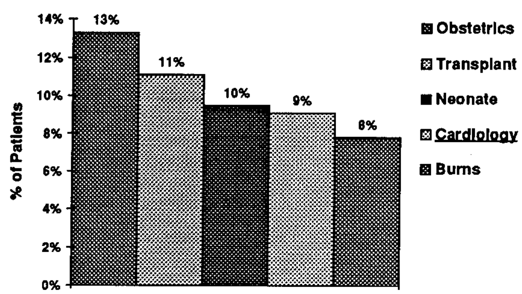

Figure 1. Urgent AE FY 93: the top 5 medical specialty codes of the 497 Urgent AE patients in fiscal year 1993.

High risk obstetric patients (preterm labor, preeclampsia) and preterm infants together accounted for nearly one quarter of our Urgent AE requirements.

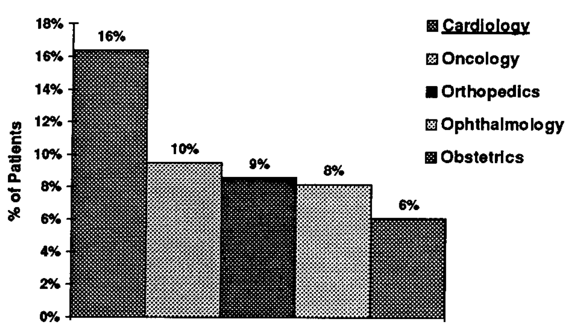

Figure 2. Priority AE FY 93: the top 5 medical specialty codes of the 525 Priority AE patients in fiscal year 1993.

These five specialties - cardiology, oncology, orthopedics, ophthalmology, and obstetrics - represented our most frequent reasons for Priority AE.

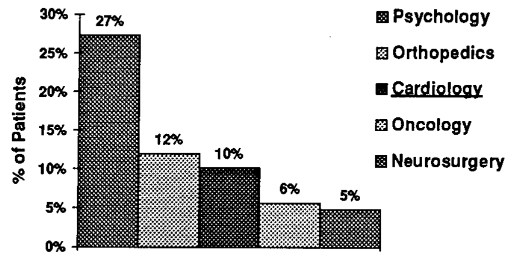

Figure 3. Routine Inpatient AE FY 93: the top 5 medical specialty codes of the 14961 Routine Inpatient AE patients in FY 93.

As you can see, psychiatric diagnoses accounted for over one quarter of our Routine inpatient AE. Of note is that half of these psychiatric patients were going for Alcohol Rehabilitation treatment.

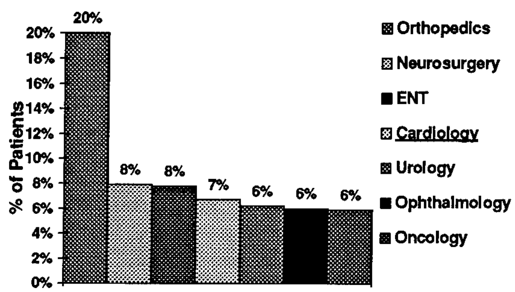

Figure 4. Routine Outpatient AE FY 93: the top 5 medical specialty codes of the 20178 Routine Outpatient AE patients in fiscal year 1993.

One fifth of our Routine outpatient AE patients were orthopedic patients.

Cardiology was the **only** medical specialty that was among the top five in all four AE movement categories. Obviously cardiology patients represent a high volume of AE patients. Additionally, they represent a higher risk group of AE patients.

5.2 AE Key Processes

Six main processes were identified as potential key AE processes. There were three to seven subprocess areas under each key process:

Regulating:
Patient Report
Number of Nights in AE
Number of Enroute Stops
Equipment Requested

Scheduling:
Time in AE System
Ground Time Awaiting AE
Unexpected Delays
Length of Patient's Day

Preparation For Flight:
Physician Documentation
O2 or Altitude Restriction
Equipment/Supplies
Medications
Narrative/Medical
Patient Education
Medical Attendant Skills

Stresses of Flight:
Hypoxia
Pressure
Temperature
Dehydration
Records Fatigue
Noise
Vibration

Equipment/Aircraft Support:
Availability
Malfunction
Equipment Waivers
Other Problems

In Flight Nursing Care and Practice:
Nursing Report
Standards of Care
Time Away From Direct Patient Care

5.3 Screening Indicators and Variables

Fourteen adverse outcome indicators were screened for during the in-flight and ASF study periods. Fifteen process discrepancies were screened for during the in-flight portion of the study only. Numerous variables in addition to the previously noted key processes and process discrepancies, were analyzed to determine if any affected clinical outcomes in AE.

Table 1. Adverse Outcome Indicators.

- Death In-Flight
- Cardiac/Respiratory Arrest
- Unplanned Extubation
- Aspiration
- Unanticipated Need for or Increase in O2 or Ventilatory Support
- As Above, for Circulatory Support
- Loss of Pulse in Limb
- Chest Pain or Dysrhythmia
- Birth In-Flight
- Neurologic Deficit
- Deterioration in Mental Status
- Trapped Gas
- Myocardial Infarction
- New Pain in Ortho Pt

Table 2. Process Discrepancy Indicators.

- Pt Inappropriately Categorized
- Pt Not Prepared for Flight
- Pt Not Stable for Flight
- Lack of Required Special Equipment
- Inpatient Without Records or Narrative Summary
- Patient Condition Not As Briefed or Expected
- Call to Physician for Orders Not Documented on AE Chart
- Medications Not Sent With Patient
- Medications Not Received In-Flight
- Treatments Not Received In-Flight
- Ground Transportation Not Meet Patient Needs
- Medical Attendant Skills Not Match Patient Needs
- DNR Paperwork Incomplete
- Safety Concern
- Diet Problems

Table 3. Variables Analyzed.

Patient Information
- Demographics: Age, Sex, Military Status, Litter?, Inpatient?, Diagnosis, Vital Signs, Lab Values, Alcohol Rehab?, Movement Precedence
- Special Requirements: O2, Altitude Restriction, Medical Attendant, Medications, Equipment, Limited Time in AE System
- Other: Originating and Destination Facility, Preparation for AE, Significant Past Medical History, Previous Problems With AE or Flight

Mission Information
- Aircraft: Mission Number, Aircraft Tail Number, Aircraft Problems, Cabin Altitude
- Time From Pick-up to Delivery

5.4 AE Clinical Outcomes

During the in-flight study period 28199 patients were air evaced. There were 26 adverse outcomes in 24 patients for a rate of 0.9 per 1000 patients. Cardiac patients represented 7.2% of patients air evaced and 37.5% of AE patients with adverse outcomes. There were 282 process discrepancies for a rate of 10 per 1000 patients - 10 times the adverse outcome rate.

During the ASF study period 12104 patients were air evaced. There were 35 adverse outcomes in 35 patients for a rate of 2.9 per 1000 patients. Two thirds of these were ear or sinus barotrauma. Cardiac patients represented 7% of patients air evaced and 11.4 % of those with adverse outcomes during the ASF study period.

Table 4. Baseline AE Clinical Outcomes

	In Flight	*In ASFs*
Study Period	15 Feb-31 Aug	1 Aug-31 Oct
Total Patients	28199	12104
Total Adverse Outcomes	26 (in 24 pts)	35 (in 35 pts)
Adverse Outcome Rate Per 1000 Pts	0.9 (0.7*)	2.9 (0.99*)
% Cardiac Dx in Total Patients	7.2	7.0
% Cardiac Dx In Pts With Adverse Outcomes	37.5 (45*)	11.4 (33.3*)
Total Process Discrepancies	282 (in 193 pts)	N/A
Process Discrepancy Rate Per 1000 Pts	10	N/A

(* rate with ear/sinus blocks factored out)

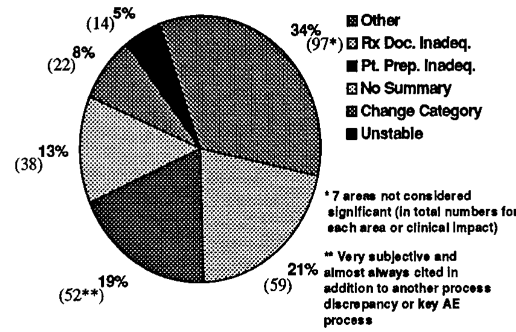

Figure 6. AE Process Discrepancies. Data gathered for the in-flight portion of the study only. There were 282 discrepancies in 193 patients. The rate for process discrepancies was 10 times the adverse outcome rate.

5.4.1. In-Flight Outcomes

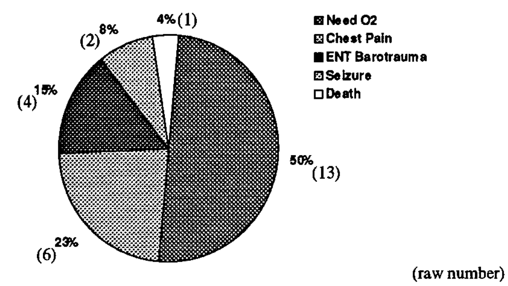

Figure 5. In-Flight Adverse Outcomes. There were 26 outcomes in a total of 24 patients

The unanticipated need for O2 and development of chest pain accounted for almost three quarters of the in-flight adverse outcomes. Two of the six patients with chest pain were also reported with unanticipated need for O2. The seizures occurred in known seizure patients. The single death in the study period occurred in a terminally ill, DNR patient.

Five discrepancies - inadequate physician documentation, inadequate patient preparation for AE, no narrative summary, change in patient category from ambulatory to litter, and unstable for flight - accounted for two thirds of the total discrepancies.

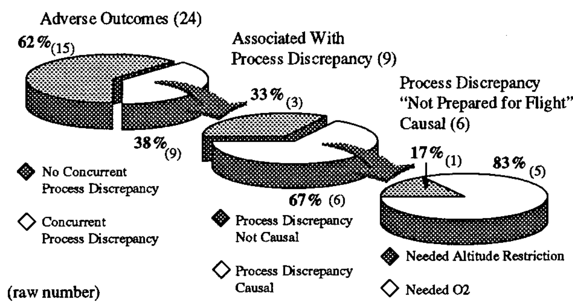

Figure 7. In-Flight Adverse Outcomes With Concurrent Process Discrepancies.

Nine of the patients with adverse outcomes also had concurrent process discrepancies. In two thirds of these, the process discrepancy was the cause of the adverse outcome. In all 6 of these cases the causal process discrepancy was in the category "Not prepared for flight". The histories of these patients follows:

1. An alcohol rehabilitation patient with a history of upper respiratory infection developed an ear block on Day 1 of his AE. He RON'd in an ASF between Day 1 and 2 of AE. The ASF flight surgeon cleared the patient to fly by telephone

without examining the patient. The patient developed a second more severe ear block on the second day of his AE.
2. A patient with rectal cancer and lung metastases did not have O2 ordered for flight. He developed shortness of breath in-flight which responded to O2.
3. A patient with respiratory failure requiring frequent suctioning and O2 while in the hospital was sent to the flight line in a bus without an attendant, O2 or suctioning capability. He developed severe respiratory distress on the flight line and was treated and returned to the hospital.
4. An ambulatory patient with cardiomyopathy and CHF developed chest pain and shortness of breath on day 1 of AE. He responded to O2 and being placed on a litter. His symptoms were reported to the ASF flight surgeon. The flight surgeon did not order O2 for flight nor change the patient to litter category. His symptoms recurred the next day during flight.
5. A patient with brain cancer and an unreported history of CAD developed chest pain responsive to O2, NTG, and being placed on a litter. No O2 for flight had been ordered.
6. A patient with intervertebral disc disease and an unreported history of pericarditis developed chest pain in-flight. His symptoms resolved with O2. No O2 had been ordered for flight.

All five patients who required O2 but did not have O2 ordered had significant cardiopulmonary disease. In two of these, this history was not provided to AE. One patient with severe pulmonary disease requiring continuous O2 was transported to the flight line without O2 and without narrative summary. He was unstable for flight at the flight line and refused for AE.

5.4.2. ASF Outcomes

Because some adverse outcomes may not become apparent until after the actual flight patients RONing in ASFs were screened for an analogous set of adverse outcome indicators.

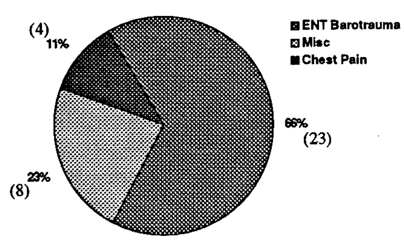

Figure 8. ASF Adverse Outcomes. There were 35 outcomes in 35 patients.

Ear and/or sinus barotrauma accounted for two thirds of the ASF adverse outcomes. The four patients with chest pain had developed it in flight but did not report their symptoms until reaching the ASF. The miscellaneous outcomes were different for each patient and none were clinically serious.

5.4.3. Combined Adverse Outcomes

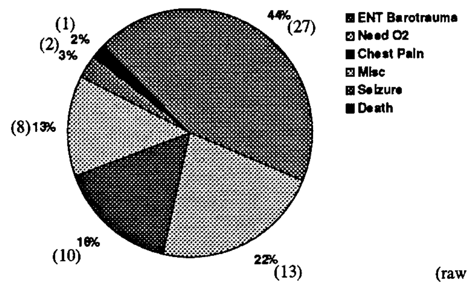

Figure 9. Total Adverse Outcomes. There were 61 outcomes in 59 patients.

These totals were used to analyze possible associations between failure of key AE processes and development of adverse outcomes. Two areas appear to be the most critical to achieving good outcomes in AE - preparation for flight and stresses of flight.

To verify this apparent relationship, we analyzed whether any of the adverse outcomes had reported key process failures associated with the development of the outcome.

5.5 AE Key Processes Which Impacted Outcomes

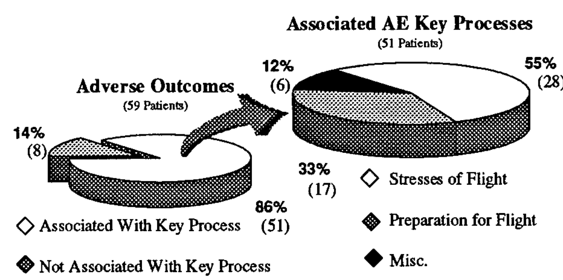

Figure 10. Key AE processes Which Impacted AE Outcomes.

Eighty -six percent of the adverse outcomes were associated with failure of a key process. Eighty-eight percent of these failures occurred in two key processes - stresses of flight and preparation for flight.

5.5.1. Stresses of Flight Which Impacted AE Outcomes
Almost all of the adverse outcomes associated with the AE key process "stresses of flight" were caused by two areas - pressure change and hypoxia.

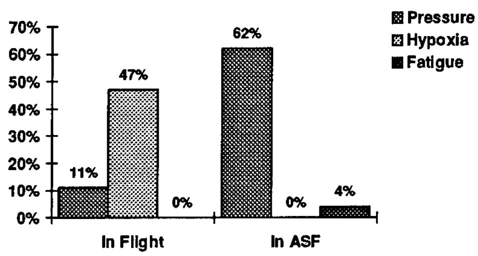

Figure 11. Stresses of Flight Which Impacted Outcomes in AE.

In flight, hypoxia was the most significant stress. All of these patients were those who had an unanticipated need for O2 or developed chest pain. In the ASF, pressure change causing ear or sinus barotrauma was the primary stress. These numbers add up to more than 100% because some patients had more than one stress of flight cited.

5.5.2. Preparations for Flight Which Impacted AE Outcomes
The adverse outcomes associated with the AE key process "preparation for flight" were caused by five subprocess areas.

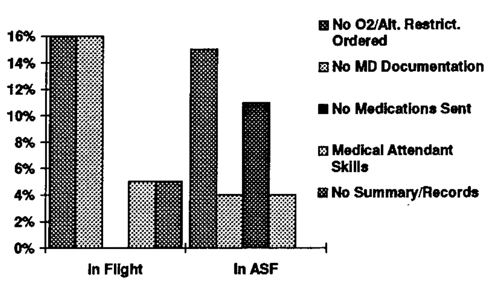

Figure 12. Preparation for Flight Areas Which Impacted Outcomes in AE

As with the stresses of flight, there are significant differences between In-flight and ASFs. In-flight, the area "lack of order for O2 or altitude restriction" was cited in patients who had unanticipated need for O2 and/or developed chest pain in flight. In the ASFs, the same area was cited for patients with known upper respiratory symptoms who developed ear blocks. "Lack of physician documentation/orders" was cited four times more frequently in-flight than in the ASFs. Most probably this difference occurred because physicians are immediately available in the ASFs but are not normally present on AE flights. The same reasoning applies to "no summary/records sent with patient" being cited by the AE crews but not the ASFs. "No medications sent with patient" was cited by ASFs but not in-flight. The likely reason for this is that most flights are too short in duration for lack of medication to become an issue. However, when that patient without medications remains overnight in an ASF, the ASF flight surgeon must write the medication orders that the referring physician failed to do.

6. CONCLUSIONS AND RECOMMENDATIONS

The lessons learned from this study confirmed the "practice wisdom" of AE personnel. There are a number of process discrepancies but in spite of that our AE patients do well. Any process discrepancies that occur are corrected by AE personnel.

Certain patients are, as expected, at higher risk from AE. Patients with limited cardiopulmonary reserve require O2 for flight and in some instances even an altitude restriction to maintain adequate tissue oxygenation.

Preparation for flight and the stresses of flight have the most impact on clinical outcomes in AE. The main areas noted for improvement in this study were patient preparation for flight, physician documentation, and for patients requiring medical attendants, ensuring the attendants' skills match the needs of the patient.

Obviously, there are differences between the patients in our study and patients seen in wartime, humanitarian, peace keeping, or disaster relief efforts. In war and military operations other than war, the patients will be more acutely ill and with less reserves to withstand the stresses of flight. More will be unstable or recently stabilized. In wartime, 80% are expected to be litter patients. Many will require medical attendants other than the AECMs. The lessons learned from the Care in the Air study are critical in medevac of unstable or acutely ill or injured patients.

Special attention to O2 requirements and altitude restrictions is crucial in patients with limited cardiopulmonary reserve, anemic patients, patients in the recent post-operative period, and patients with actual or potential trapped gas in critical body cavities. Procedures such as inserting catheters, IVs, and intubations are very difficult to accomplish in the often dark, dirty, and crowded aircraft environment. If a patient is likely to

need a procedure it should be accomplished before the AE flight.

Physician documentation of care required during medevac and until arrival at the destination medical facility is crucial. Aeromedical Evacuation personnel must have a concise transfer summary, complete orders, and all pertinent medical records to care for AE patients en route.

Finally, the skills of the medical attendants must match the patients' needs. For patients requiring a cardiac monitor, the attendant must be certified in advanced cardiac life support; for patients on ventilators the attendant must be able to both manage the ventilator and reintubate the patient should it be necessary. Advanced Trauma Life Support certification should be mandatory for medical attendants transporting acutely injured patients.

Effect of hypoxia on arterial blood gases in subjects with lung dysfunction

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Introduction

Although air transportation is an efficient way of evacuating casualties out of combat zones, even the mild hypoxia in a pressure cabin may adversely affect the oxygen supply of subjects whose lung function is compromised. Obviously, the wounded are difficult to study systematically. It is, however, possible to evaluate pulmonary limitations of oxygen transport by investigating persons with various lung diseases.

This paper presents the effects of very light physical work in hypoxia on subjects with chronic obstructive lung disease (COPD). These patients are characterized by obstruction of the airways, resulting in low expiratory air flow rates, and low maximal ventilation rates (Cotes 1993). We analyze the consequences of inadequate alveolar ventilation and increased resistance to diffusion in the lung for oxygen partial pressures in alveoli and arterial blood, and on arterial oxygen saturation. We also try to evaluate the usefulness of standard clinical tests in predicting susceptibility of lung patients to hypoxia.

Methods

Experimental procedures

Sixteen subjects with the clinical diagnosis chronic obstructive pulmonary disease volunteered for the project, after the experimental procedure and risks connected with the experiment had been carefully explained. They were examined prior to the experiments to exclude subjects with other diseases. During the experiment arterial blood samples were obtained from an indwelling catheter in *a. brachialis*, and SaO_2, pO_2, pCO_2, bicarbonate, and pH were determined using a Radiometer ABL 300. Ventilation, oxygen consumption ($\dot{V}O_2$) and CO_2 production ($\dot{V}CO_2$) were calculated from measurements of ventilation and fractions of oxygen and CO_2 in mixed expiratory air using an Oxycon Champion equipment (Erich Jaeger GmbH, Würtzburg, Germany). Alveolar ventilation ($\dot{V}a$) was calculated from values for pulmonary ventilation ($\dot{V}e$), mixed expiratory CO_2 pressure ($peCO_2$) and arterial pCO_2, assuming that the pulmonary pCO_2 equals alveolar pCO_2 (Jones 1988).

Measurements were done at rest and during work on an ergometre bicycle. The load increased by 1W per 12 seconds, from 10W until the patient could no longer continue cycling. This protocol gives the subject a sensation of a gradually increasing load with no discernable steps. Measurements were done at ground level, and at simulated altitudes of 8000 and 10 000 ft.

Standard bellows function tests (vital capacity (VC), forced expiratory volume in one second (FEV_1), maximal voluntary volume (MVV) and single-breath carbon monoxide transfer factor (TLCO)) were determined at ground level with a MasterLab equipment (Erich Jaeger GmbH, Würtzburg, Germany). FEV_1 ranged from 720 to 2080 ml, MVV from 20 to 75 l min^{-1}, and TLCO from 1.5 to 8.4 mmol min^{-1} kPa^{-1}.

Pulmonary shunt was calculated with the Siggaard-Andersen blood gas computer programme, using blood gas values after the subjects had been breathing pure oxygen for 15 minutes at ground level.

Analysis

The driving force for diffusion is the difference in oxygen partial pressure ($\Delta pO_{2,A-c}$) between alveolus and capillary. If one measures the partial pressure of CO_2 in arterial blood, one can estimate the alveolar pO_2 by the *alveolar air equation* (Jones 1988):

$$(1) \quad p_AO_2 = (pB - pH_2O)F_iO_2 - \frac{p_ACO_2}{RQ}(1 - (1 - RQ)F_iO_2)$$

The alveolar partial pressure of CO_2 is determined exclusively by the ratio between CO_2 output and alveolar ventilation. If this relationship is used in a simplified version of the alveolar air equation, where the expression in parenthesis in the last term is disregarded, the difference between the pO_2 in the inspired air (saturated with water vapour at 37°C) and in the alveoli depends only on the ratio between oxygen uptake and alveolar ventilation:

$$(2) \qquad \Delta pO_{2,\,i-A} = \frac{\dot{V}O_2}{\dot{V}a} = \frac{1}{Eq_aO_2}$$

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where $EqaO_2$ is the *alveolar ventilatory equivalent of oxygen.* The relationship is independent of altitude (Ernsting 1988; Ernsting and Sharp 1988).

In the normal lung, capillary blood comes very close to equlibrium with the aleolar gas in only a fraction of the time it takes for the blood to pass the capillaries (the transit time). If the diffusion barrier is pathologically increased, however, an equilibrium may not be reached within the transit time. In that case, oxygen uptake is diffusion limited, and if one can disregard the non-linearity of capillary oxygen pressure vs time, the oxygen uptake would be proportional to the difference in oxygen partial pressure between aleoli and capillaries. Hence,

$$\dot{V}O_2 = D \cdot (p_AO_2 - p_cO_2) \tag{3}$$

where D is a transfer factor for oxygen. If we assume that the transfer factors for carbon monoxide and oxygen are proportional, and that arterial and capillary pO_2 are proportional, equation (3) predicts that the alveolo-arterial difference in oxygen pressure is proportional to $\dot{V}O_2/TLCO$.

The partial pressure of oxygen may drop even further after leaving the capillaries as a result of admixture of venous blood that has passed through non-ventilated or poorly ventilated parts of the lung, and so has not become oxygenated. This is called pulmonary shunt.

We must therefore assume that the difference i pO_2 from atmosphere to arterial blood can be treated statistically as a linear combination of the terms $\dot{V}O_2/\dot{V}a$, $\dot{V}O_2/TLCO$, and pulmonary shunt.

Effects of altitude, oxygen uptake, ventilation, diffusion capacity or combinations of these parameters on partial pressures of blood or alveolar oxygen were tested with multiple regression analysis or analysis of covariance, using JMP v. 2.05 for Macintosh (SAS institute, 1989-91)

Results and Discussion

Responses to work load in hypoxia

Oxygen saturation in hypoxia varied widely, both at rest and exercise. The most pronounced fall in saturation usually occurred at the beginning of the exercise, with only a slight further decrease as the load increased. During the recovery phase the oxygen saturation increased, and could occationally reach higher values than at rest (Figure 1).

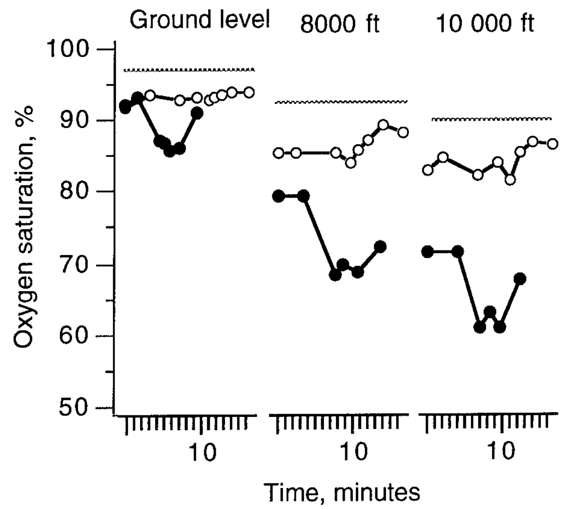

Figure 1. Decrease in oxygen saturation of arterial blood during a graded work load at ground level, 8000 ft and 10 000 ft in two subjects with chronic obstructive pulmonary disease. The first two points in each series are resting values, and the last three from the recovery from work. The stippled horizontal lines represent expected normal values.

Oxygen transport and partial pressure differences

The theoretical relationship between p_AO_2 and the ventilation equivalent was confirmed by our measurements. Figure 2 shows the very close relationship between the difference in pO_2 from atmosphere to alveoli ($\Delta pO_{2,i-a}$) and the ventilatory equivalent for oxygen. The slightly but significantly lower values at 8000 ft could be due to a systematically higher RQ at altitude (Ryg, Christensen, Neslein & Andersen, unpublished data). Nitrogen wash-out from the tissues would violate the basic assumption of the alveolar air equation (that $\dot{V}_{N_2in} = \dot{V}_{N_2out}$), but although the magnitude of this effect is difficult to estimate, it is probably small.

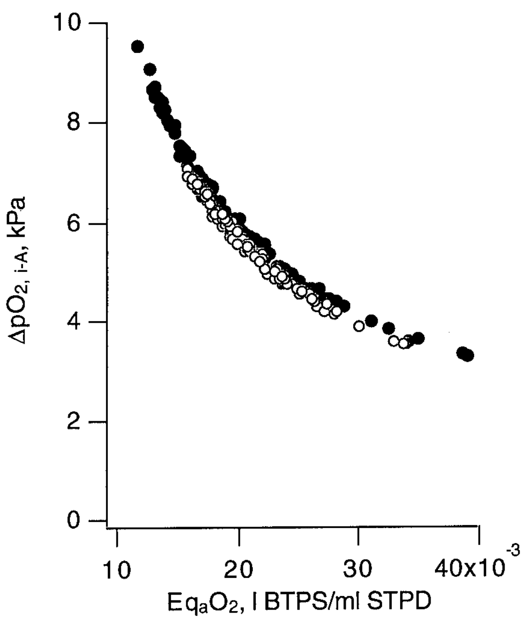

Figure 2. Difference in inspired and alveolar pO2 versus the alveolar ventilation equivalent for oxygen. Closed symbols: ground level; open symbols: 8000 ft altitude

Alveolo-arterial difference

From equation (3) one would expect that, when capillary blood does not get in equilibrium with alveolar air, the difference in oxygen pressure from alveoli to arteries is proportional to oxygen uptake divided by the carbon monoxide transfer

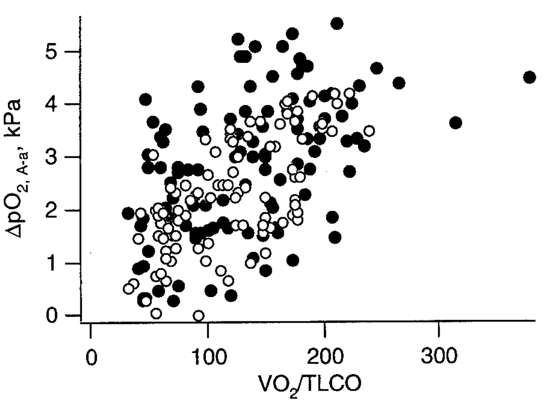

Figure 3. Alveolo-arterial pO_2 difference as a function of the ratio between oxygen consumption and TLCO

factor, TLCO. Figure 3 shows that there was indeed such a positive correlation, which was independent on altitude. TLCO is constant within each subject, but there was considerable between-subject variance, and the correlation demonstrated in Figure 3 is caused by a combination of a negative correlation with TLCO and a positive correlation with oxygen uptake. When we also considered pulmonary shunt in a multiple regression analysis, we found statistically significant effects of both shunt ($F_{1,183}$ = 36.1) and the $\dot{V}O_2$/TLCO ratio ($F_{1,183}$ = 97.0). However, as is evident from large variability in Figure 3, the predictive value of the two regressors was low, as the combined effect of shunt and diffusion limitation could only explain about 40% of the total variation in the alveolo-arterial pO_2 difference. One evidently needs better diagnostic tools to characterize deficiencies in the diffusion step.

Since the total drop in oxygen partial pressure equals the sum of the two steps—from atmosphere to alveoli and from alveoli to blood—it is not surprising to find that the total $\Delta pO_{2,i\text{-}a}$ was significanly affected by the three factors ventilation equivalent (or rather, its inverse, $F_{1,183}$ = 277), the $\dot{V}O_2$/TLCO ratio ($F_{1,183}$ = 91.5), and pulmonary shunt ($F_{1,183}$ = 27.1), and that the combined effects could account for 73% of the total variation in the difference in pO_2 from inspired air to arterial blood ($\Delta pO_{2,i\text{-}a}$).

Oxygen saturation in arterial blood

How do the differences in oxygen partial pressure translate into differences in oxygen saturation? Because of the shape of the hemoglobin dissociation curve, the effect on saturation of a larger difference in pO_2 from atmosphere to arterial blood is expected to be much more pronounced at altitude.

This is clearly demonstrated when oxygen saturation is plotted against the ventilatory

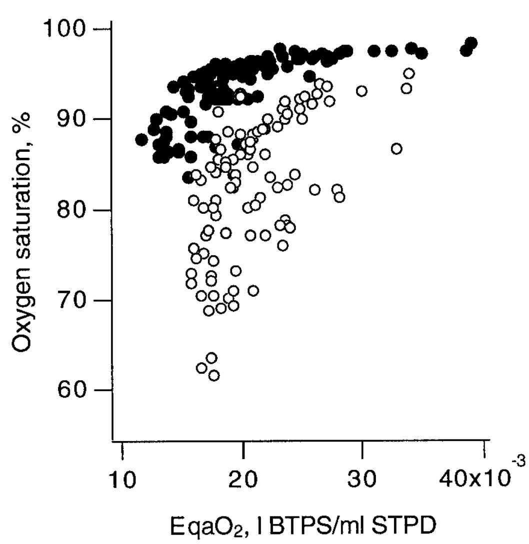

Figure 4. Oxygen saturation decreases with decreasing alveolar ventilation equivalent. with a more pronounced effect at altitude (open symbols) than at ground level (closed symbols:

equivalent (Figure 4) and the oxygen uptake to TLCO ratio (Figure 5), i.e., two of the factors that

we found to influence the inspired to alveolar and alveolar to blood pO_2 differences, respectively. The slopes of regressions of saturation and ventilation equivalent and $\dot{V}O_2$/TLCO ratio are much steeper at 8000 ft than at ground level, thus demonstrating that the consequences of an impaired lung function become more serious with increasing altitude.

Because the saturation is influenced by both $\dot{V}O_2$/TLCO and ventilatory equivalent, there is a large variance, especially at altitude, when saturation is plotted against either of the two factors. Samples with low saturation as related to their ventilatory equivalent had a high $\dot{V}O_2$/TLCO ratio, and are values from a subgroup of eight patients during exercise or early recovery. This subgroup had significantly lower TLCO than the remaining eight (unpaired t-test, $p<0.005$). Vice versa, samples with low saturation for their $\dot{V}O_2$/TLCO ratio had low ventilatory equivalents.

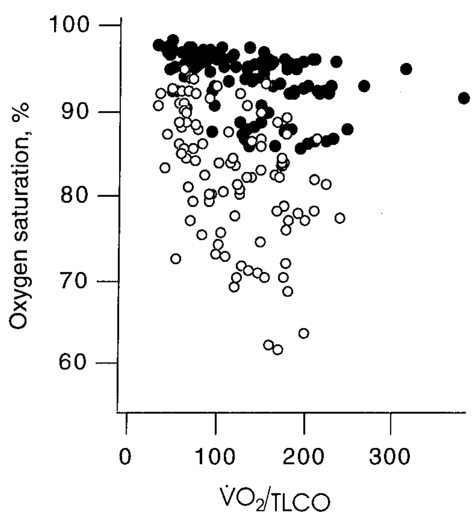

Figure 5. Oxygen saturation decreases with increasing VO2/TLCO rato, with a more pronounced effect at altitude (open symbols) than at ground level (closed symbols)

Can oxygen saturation at altitude be predicted?

So, differences in pulmonary ventilation, resistance to diffusion across the lung, and pulmonary shunt account to a large extent for changes in arterial oxygen saturation when the organism is challenged by reduced oxygen supply and increased oxygen demand. However, in an emergency one has to balance the risk and cost of reducing flying altitude, the cost of bringing extra oxygen supply, and the risk of hypoxemia to the patient. One therefore needs to *predict* the response, either from a clinical assessment, or from simple, standardized tests done on ground, *before* the flight. Myhre and Christensen (1982) reported a correlation between bellows function and resting arterial oxygen saturation at altitude in a group of persons suffering from various lung diseases. However, in the present investigation, standard bellows function tests — such as the forced expiratory volume in one second (FEV_1) or maximal volountary ventilation (MVV) — although significantly correlated to the ventilatory equivalent and alveolar pO_2, had little predictive value. Either of them could explain less than 20% of the total variation in the ventilatory equivalent, and hence the alveolar pO_2. The cause of the inadequate ventilation may therefore be only partly related to the obstructive disease as such, and more to general control of pulmonary ventilation. Likewise, indicators of ability to function in daily life — maximum walking speed, ortopnoea, etc — had little predictive value for oxygen saturation values, although there were statistically significant influences.

Conclusion

The differences in oxygen partial pressures from atmosphere to alveoli, and from alveoli to arterial blood depend on the matching of alveolar ventilation and diffusion capacity to oxygen consumption, but are independent of barometric pressure as such. Standard tests of bellows function or diffusion capacity, without consideration of oxygen demand, were not able to predict changes in arterial oxygen pressure.

Because of the nonlinear shape of the oxygen dissociation curve, the effect of impaired lung function, whether it is insufficient ventilation or poor diffusion capacity, is much more dramatic at altitude than at ground level. How a patient functions in daily life is therefore not a reliable indicator of his response to hypoxia.

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CHANGES IN THE MEDEVAC MISSION RESULT IN AN INCREASED ROLE FOR THE FLIGHT SURGEON

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1. SUMMARY
Historically physicians were involved in the development of aeromedical evacuation (medevac) and flight surgeons flew as crewmembers on the first US military medevac flights. However, since World War II flight surgeons have not been routinely assigned to operational medevac units. The aeromedical literature addressing the role of physicians in medevac is controversial. Recent contingencies involving the US Air Force (USAF) have required the augmentation of medevac units with flight surgeons. Since 2 February 1993, USAFE has moved 221 patients on 27 missions out of the former Yugoslavia -- most of these missions had a flight surgeon on the crew. Because advanced medical information on the status of these patients is often non-existent, the presence of a physician on the crew proved lifesaving in some instances. In peacetime operations, there has been a recent trend in the European theater for the USAF to move more unstable patients. Beginning in 1993, USAFE assigned three flight surgeons to the medevac squadron. Dedicated medevac flight surgeons have proven to have the specific experience and training to perform effectively in the role of in-flight medical attendant. Their understanding of the system also makes them more effective in medical validation than non-medevac flight surgeons. In addition, they are effective in negotiating with referring physicians about the urgency of movement, required equipment, the need for medical attendants, etc. These flight surgeons provide medical coverage of transiting patients in the Aeromedical Staging Flight (ASF), thus providing needed continuity in the medevac system. In conclusion, dedicated medevac flight surgeons fill a unique and valuable role. Recommend that agencies with medevac units consider assigning flight surgeons to these units.

2. HISTORY OF USAF AEROMEDICAL EVACUATION

2.1 The Role of Flight Nurses in Medevac
The need for flight nurses as aeromedical attendants was initially questioned; it was felt that a medical technician could handle inflight medical emergencies satisfactorily and that nurses could be better utilized in hospitals (1). In 1942 the U.S. Army recognized the requirement and the first flight nurses class graduated in 1943 (1). In fact, critically ill patients were frequently moved during World War II including patients still under the influence of anesthesia following "front-line" surgery (1). Flight Nurses demonstrated their value during World War II, especially in the Pacific Theater with its very long distances; 54% of the patients transported in this theater were litter patients and the average enroute distance was 3,600 miles (19 hour)(1). Overall a total of 1,172,648 patients were evacuated by air during World War II by the United States with an overall mortality rate of only 4 per 100,000 transports (1).

2.2 The Role of Flight Surgeons in Medevac
Although aeromedical evacuation has been used since 1870 (2), the first air transport of patients in the United States was in a JN-3 ("Jenny") which in 1918 was converted to carry a special litter in the rear cockpit (1). The JN-4 carried a flight surgeon to the scene of aircraft crashes and subsequently transported the injured crewmembers to hospital care (1) . The first operational units dedicated to medevac were not organized in the US military until 1943 (2)(1). Medevac flights were headed by a flight surgeon and consisted of 6 flight nurses and 6 medical technicians (1). The role of

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the flight surgeon was largely administrative, but he was called upon to accompany selected high risk patients (1).

Since World War II, the USAF has assigned flight surgeons to headquarters units (for example at Scott Air Force Base, Illinois) in positions managing world-wide aeromedical evacuation. In Vietnam inter-hospital medevac was largely limited to relatively stable patients and flight surgeons were not routinely assigned to medevac units (3). Until just recently, flight surgeons have not been assigned to individual operational medevac units in the European or the Pacific theaters. Physicians were provided during contigencies only. In the past, flight surgeons assigned to the base medical treatment facility provided rotating on-call support to validate urgent and priority patients. When medical attendants were required and the referring facility could not provide them, medevac units borrowed flight surgeons assigned to either the base medical treatment facility or to other operational flying units within the theater. Approximately two years ago a physician was assigned as the commander of the air evacuation squadron in the Pacific theater. The manning standard for the USAF medevac unit in Europe (86th Air Evacuation Squadron), included approximately 110 personnel (42 flight nurses, 47 medical technicians, and 21 medical administrative) and had not changed in over 20 years.

As part of a trend toward decentralized management, HQ USAFE took responsibility for managing medevac within this theater in 1992. HQ USAFE and the 86th Air Evacuation Squadron (86 AES) recognized the need for assigned flight surgeons. In 1993-1994 three US Air Force flight surgeons were assigned to full-time medevac duties at the 86 AES. They underwent rigorous training on C-9, C-130, and C-141 aircraft, maintain flying currency, and regularly log flight time on medevac missions. Recently an additional physician was assigned to this air evacuation squadron as the commander.

3. THE NEED FOR PHYSICIANS IN MEDEVAC - LITERATURE REVIEW

3.1 The Need for a Physician Medical Attendant in Civil Medevac

The need for physicians on aeromedical evacuation flights is controversial (4). The need for physician medical attendant may differ depending on the type of patient (neonatal, trauma, cardiac, etc.), the mode and duration of transport (helicopter vs fixed wing, etc.), and type of response (whether the medevac is a response to the scene or an inter-hospital transfer). USAF medevac is primarily used to accomplish inter-hospital transfer of a wide variety of types of patients using fixed-wing aircraft. Currently most US civil medevac services provide two medical crewmembers: of these 11% of helicopter programs and 2% of fixed wing programs include physicians on the team (4).

Four studies have compared outcome parameters among patients transported by a physician led team compared with physician-absent teams (see Table I.A.). Two of these studies (5,6) addressed helicopter response to an accident scene to transport trauma patients. One study addressed primarily the inter-hospital transfer (94.5% of patients were transfers and 5.5% were picked up directly at the scene) by helicopter of adult patients with a variety of diagnoses (7). The fourth study addressed the inter-hospital transfer by either ground transport or fixed wing aircraft of neonatal patients (8). In two of these studies, physician participation was randomized (5) (8). Only one of these four studies demonstrating a significant difference in mortality between the physician and non-physician groups (5).

Several studies have subjectively estimated the proportion of flights needing physician skills or judgement without actually comparing outcome parameters of flights with physician participation (see TABLE I.B.). One of these studies addressed helicopter response to an accident scene to transport trauma patients and found that major intervention was required in 45% of the cases (9). Two studies addressed the inter-hospital transfer by helicopter (in the first 97% and in the second 85-90% of the patients were inter-hospital transfers) of adult patients with a variety of diagnoses; the first study found a physician contribution in 22% of the cases (10) and the second found a definite contribution in 25% and a possible contribution in an additional 35% (11). One study addressed the inter-hospital transfer by helicopter of adult cardiac patients and found that physician skill or judgement was necessary in 26% of the cases (12). The fifth study addressed the inter-hospital transfer of pediatric patients by either ground transport or fixed wing aircraft found that physicians were ncessary to perform procedures in 9% of the cases and were required to dispense medications in 34% of the cases (13). Overall a physician was judged to be necessary between 22% and 45% of the time.

Perhaps more important than the professional background of the aeromedical crew is actual experience in the medevac environment. In a study of the response to simulated cardiac arrest in an actual inflight environment by Advance Cardiac Life Support

(ACLS) certified medical personnel, 40-45% of teams without medevac experience performed below standards compared with nearly flawless responses by regular medevac teams (at least 9 months of medevac experience)(14). Inexperienced personnel complained about space limitations and noise (14).

3.2 Other Roles for the Physician in Civil Medevac

In addition to the flight surgeons role as a medical attendant, the role of the medical director in providing training, assuring quality control, and communicating with referring physicians is also of critical importance (4).

3.3 The Role of the Flight Surgeon in Military Medevac

Few studies have addressed the need for physicians in military aeromedical evacuation. The Israeli Defense Force doctrine is that physicians will act as crewmembers on all medevac flights (15,16,17). Of 884 moderately severe or severe casualties evacuated by air between 1973 and 1976 with a physician as an inflight medical attendant, 96.5% did not deteriorate during transport (15). The study concludes that flight surgeon participation in medevac is "highly valuable" during both peacetime and wartime (15).

Recently the need for augmenting USAF medevac with dedicated flight surgeons during wartime and contingencies has been recognized (3). Contingencies have resulted in an increased need to transport more unstable patients. The terrorist bombing of the US Marine Barracks in Beirut in 1983 resulted in the medevac of 88 casualties within 12 hours; 19 of these were critically injured and one died during transport (3). During the U.S. Invasion of Panama in 1989, 192 patients were evacuated by air in the first 24 hours. Initially only 2 flight nurses and 3 aeromedical technicians were assigned to each flight. Subsequently a physician was added to each crew although some of these physicians were not specifically trained for this mission (3). To remedy this situation, during the Gulf War, 32 flight surgeons were directly assigned to aeromedical evacuation and training requirements were specified (3). These flight surgeons proved effective in judicious patient validation for transport, proper patient preparation for safe transport, and in cost effective utilization of medevac aircraft (3).

4. RECENT CHANGES IN THE EUROPEAN THEATER

4.1 Recent Contingencies in the European Theater

Following the Gulf War, flight surgeons were still not routinely assigned to medevac squadrons during peacetime operations. In this theater there has been a continued demand for urgent medevac missions in support of contingencies (PROVIDE COMFORT, DENY FLIGHT, RESTORE HOPE). These contingencies have required that urgent patients be evacuated on short notice, often without advanced knowledge of the types of injuries involved. Since February 1993, 221 patients, including 115 litter patients and 105 ambulatory patients, have been evacuated by air out of Bosnia on 27 missions. Most of these missions had a flight surgeon on the crew. Because advanced medical information on the status of these patients is often nonexistent, the presence of a physician on the crew has proved lifesaving. For example, flight surgeon involvement was critical in the recognition and treatment of hypothermia in multiple patients on a medevac mission out of Sarajevo.

4.2 Changes in the Standard of Medical Care

The standards of medical care have evolved tremendously since medevac was organized during World War II. Due to changes in both diagnostic technology (e.g., CT Scan, MRI) and treatment modalities (e.g. fibrinolytic therapy, coronary artery bypass surgery, newborn intensive care) patients are moved by medevac today which in the past did not require movement. The USAF aeromedical evacuation system regulations have prohibited the transfer of many categories of unstable patients. For example, regulations do not recommend the routine transfer of patients who are beyond their 34 week of pregnancy or acute myocardial infarction (MI) patients within their first ten days following their MI. These and other categories of critically ill patients are now regularly transported in this theater (18). For example, a pediatric patient on extra-corporeal membraneous oxygenation (ECMO) was recently air evacuated.

4.3 Drawdown of U.S. Forces in Europe

A decline in the number of military hospitals overseas has also contributed to an increased need to transport high risk patients. The number of USAF hospitals has declined from a 83 in 1984 (including 9 in Europe) to 62 in 1994 (only 3 in Europe). While the total number of patients undergoing aeromedical evacuation has declined, the number of patients requiring holding in the aeromedical staging Flight (ASF) awaiting transfer back to the United States has not decreased (see Figure 1). This same trend toward a decline in the number of hospitals may be anticipated in the civilian sector in the US and may be expected to increase the need for aeromedical evacuation in the civilian sector (19). In

addition, an increasing number of urgent cases require transport from remote locations such as Eastern Europe or Africa.

Although the drawdown of US Forces overseas has resulted in a decrease in the number of patients transported in the European aeromedical evacuation system, an increasing proportion of these patients are acutely ill. During the 12-month period ending in September 1993, 13,095 patients were transported either within Europe or between Europe and the United States. This is compared to 20,182 for the 12-month period ending in September 1992 and 24,653 for the 12-month period ending in September 1991. However, the number of urgent and priority missions has increased; 109 were carried out during the 12-month period ending in September 1993 compared to 111 for 1992 and 66 for 1991. Urgent patients require immediate transportation to save life, limb, or eyesight; priority patients require transport within 24 hours. Note that the proportion of urgent and priority patients has steadily increased (see Table II). In the three years from 1991 to 1993, the numbers of such patients increased 65 percent, despite a 53 percent decline in overall number of patients moved.

5. OBSERVED BENEFITS OF PHYSICIANS IN MEDEVAC

5.1 Administrative

5.1.1. PATIENT VALIDATION. Previously flight surgeons rotated patient validation duties among a larger pool of flight surgeons who were often primarily assigned as squadron flight surgeons to fighter or tactical airlift squadrons. The 3 flight surgeons currently assigned to the 86 AES work closely with the flight clinical coordination nurse. Their understanding of the system makes them more effective in medical validation and arbitrating with referring physicians about the urgency of movement, required equipment, the need for medical attendants, etc. Less explanation is necessary, confidence is engendered, and selective delegation of validation authority is possible.

5.1.2. LIAISON WITH MEDICAL REFERRING FACILITIES. Assigned flight surgeons have been valuable additions to liaison teams traveling to brief referring facilities. They have the capability and background to address physician-level issues which routinely surface during these visits.

5.1.3. TRAINING. These flight surgeons have provided extremely valuable medical training within the medevac squadron. For example, in a recent training session squadron flight surgeons explained to other squadron members the anatomy and pathology of clolesteatoma and why it does not result in difficulty clearing ears.

5.1.4. MEDICAL OVERSIGHT. In today's litigious environment enhanced medical oversight and quality assurance are essential. The assigned flight surgeons have become the "medevac experts" in this theater. They are able to identify medevac equipment and research needs.

5.1.5. CAREER DEVELOPMENT. Assigned flight surgeons will develop expertise in medevac, which they can apply in subsequent staff or command assignments.

5.2. Medical

5.2.1. AVAILABILITY OF MEDICAL ATTENDANTS. Although medical attendants are normally provided by the originating facility, many of the smaller facilities have a minimum physician staff and a physician departing a remote location on a medevac mission may not be able to return for several days. In addition, when urgent missions are required to transfer patients from naval vessels or remote areas, a physician medical attendant needs to be supplied. Having dedicated personnel has proven necessary on several occasions to allow response on short-notice, for example the evacuation of 50 wounded civilians out of Sarajevo in February 1994. Advanced medical information on the status of these patients was non-existent. Flight surgeons assigned to the AES accompanying these missions proved essential to the safe transport of the patients. For example, during transport a flight surgeon diagnosed hypovolemic shock and a plugged intravenous line in a patient with a shrapnell injury which was bleeding internally.

5.2.2. TRAINING OF AEROMEDICAL ATTENDANTS. Previously there has been difficulty finding qualified personnel to accompany certain categories of critically ill patients. Non-medevac flight surgeons have been increasingly reluctant to assume responsibility for some complicated medical patients such as those requiring respirator support. The difficulty of finding physicians to accompany these patients is compounded by the increasing scarcity of respiratory therapy technicians in this theater. The dedicated medevac flight surgeons have become familiar with medevac approved equipment and have performed very effectively in the role of in-flight medical attendant. Specific areas where medevac expertise has proven useful include airway/ventilator management, transfer of neonatal patients, assessment of changes in pulse oximeter readings, etc.

5.2.3. CONSULTATION WITH REFERRING PHYSICIANS. Requests for aeromedical evacuation are often received from inexperienced physicians in remote areas. Assigned medevac flight surgeons have the knowledge and the credibility to negotiate safe yet cost-effective transfer decisions, for example in deciding whether to launch a dedicated flight or wait for the next scheduled mission. Their familiarity with the details of the medevac system makes them effective in responding to "little questions" from referring physicians.

5.2.4. AEROMEDICAL STAGING FLIGHT. In the past flight surgeons provided only on-call support for the Aeromedical Staging Facility (ASF). Flight surgeons covering the ASF were not usually the same flight surgeons covering other aspects of the medevac system. Now flight surgeons assigned to the 86 AES assume overall responsibility for inpatient care, conduct daily rounds, and screen all ASF patients prior to flight. The system is now "seamless" as these same physicians are responsible for patient validation and for acting as aeromedical attendants if needed.

5.2.5. SQUADRON MEDICAL ELEMENT. Previously aeromedical evacuation squadrons were the only flying units in this theater without dedicated flight surgeon support. Now assigned flight surgeons also serve as the squadron medical element to medevac personnel. This ensures continuity of care and proper aeromedical disposition of aircrew members.

6. CONCLUSIONS AND RECOMMENDATIONS

Assigning flight surgeons as integral members of a medevac squadron has had both administrative and medical benefits. Dedicated medevac flight surgeons have the specific experience and training to perform effectively in the role of in-flight medical attendant. In addition, their understanding of the system makes them more effective in medical validation and arbitration with referring physicians about the urgency of missions, required equipment, the need for medical attendants, etc. These flight surgeons also provide medical coverage for transiting patients in the Aeromedical Staging Facility, thus providing needed continuity in the medevac system. In conclusion, dedicated medevac flight surgeons fill a unique and valuable role. Recommend that agencies with medevac units consider assigning flight surgeons to these units.

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TABLE I.A. STUDIES COMPARING AEROMEDICAL CREW PERFORMANCE TO DETERMINE IF PHYSICIAN PARTICIPATION EFFECTED PATIENT OUTCOME

	# PATIENTS/ CONTROLS PATIENT TYPE	MODE OF TRANSPORT	MORTALITY (physician)	MORTALITY (non-physician)
U. Calif., San Diego (Baxt)	316/258 (response to accident scene)	(H)	11 (p<.05) (16.9 predicted)	19 (N.S.) (19.5 predicted)
U.Louisville, (Hamman)	145/114 (response to accident scene)	(H)	12 (N.S.) (17 predicted)	8 (N.S.) (15 predicted)
U. Michigan (Burney)	418/241 (interhospital transfers)	(H)	17% (N.S.)	21%
U. Virginia (Cook)	179/55 (interhospital transfers of neonatal)	(G or F)	3.4% (N.S.)	0%

(H) = helicopter transport

(G or F) = Transports over distances less than 120 miles accomplished by ground, those more than 120 miles accomplished by fixed wing aircraft

TABLE I.B. RETROSPECTIVE REVIEWS ASSESSING INTERVENTIONS REQUIRED DURING AEREVACUATION TO DETERMINE IF PHYSICIAN PARTICIPATION EFFECTED PATIENT OUTCOME

	# PATIENTS PATIENT TYPE	MODE OF TRANSPORT	% MISSIONS REQUIRING PHYSICIAN
Geisinger Medical Center (Anderson)	110 (response to accident scene)	(H)	45%
Univ. Michigan (Rhee)	174 (97% inter-hospital transfer)	(H)	22%
Cleveland Metropolitan (Snow)	395 (85-90% inter-hospital transfer)	(H)	25%
Univ. Michigan (Kaplan)	104 (interhospital transfer of myocardial infarction)	(H)	26%
Children's Hosp. Alabama (McCloskey)	191 (inter-hospital transfer of pediatric)	(G or F)	43%

(H) = helicopter transport

(G or F) = Transports over distances less than 125 miles accomplished by ground, those more than 125 miles accomplished by fixed wing aircraft.

Figure 1. Aeromedical Staging Workload Data

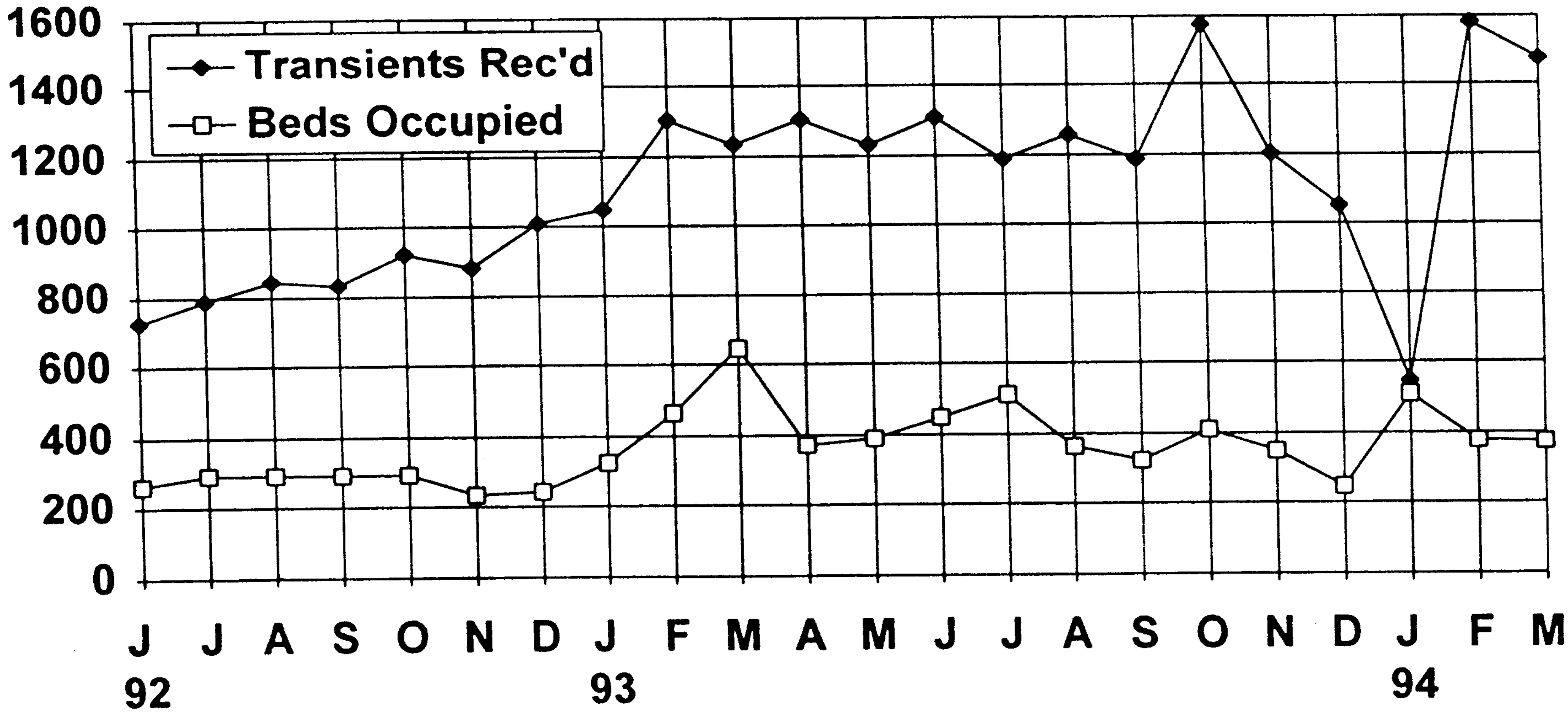

TABLE II. TOTAL NUMBER OF U.S. PATIENTS UNDERGOING AEROMEDICAL EVACUATION IN THE EUROPEAN THEATER AND THE PROPORTION OF THOSE PATIENTS REQUIRING URGENT EVACUATION

YEAR	TOTAL PATIENTS	URGENT/PRIORITY PATIENTS	% PATIENTS URGENT
1991	24,653	66	.27%
1992	20,182	111	.55%
1993	13,095	109	.83%
1994 (9 months)	7,657	66	.86%

"Flight Nurse School in the Hellenic Air Force"

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ABSTRACT
The necessity of specialized nursing personnel for air evacuated patients in peace and war time led Medical Service of the Hellenic Air Force (HAF) to train officer nurses in the USA F.N. School in order to create a similar school in our country.

This School was established in 1988 and the first FNs graduated the same year. At this moment, the training courses are for officers with a near future schedule for petty officers.

The structure and performance of school cconducted in accordance to US FN School in Brooks AFB San Antonio TEXAS, corresponded to the needs and abilities of our country.

The ultimate purposes concerning the foundation of the school are:

a) to advance the quality of nursing care
b) to install the minimum demands - standards of care for FN
c) to access FN nursing enlightment to all levels of medical personel
d) the readiness to respond in every emmergency condition involving air evacuation demands in agreement with an appropriate program
e) the attachment of education to all FN
f) to advance assurance quality with a predetermined procedure.

Course is mandatory and operates on a theoretical base with a minimum of practical application. The experiences gained from FN during the involvement in three (3) scheduled air drills were fewer than expected.

Flight nursing offers a unique and broad field to professional nursing with an opportunity to serve patients, community, integrating nursing as a basic part of aerospace medicine.

Through school activities, the personnel of the HAF have had the opportunity to be informed about the value of special knowledge about air evacuated patients, so that they are able to cooperate, whenever this is demanded.

Our primary mission is to include FNs to all air evacuation operations concerning the HAF, so that it will be possible to practice Flight Nursing knowledge on a real base.

There are about 68 nurses specialized in flight nursing, ready to respond to any situation with massive casualties during war or peace time in our country.

1. PREFACE

Neither Ikarus, as he spread his wings and dazzled by the height flew through the skies, nor the Reit brothers, as they lifted off the ground in a flying machine could imagine that the "revolution" that was to be called aircraft would some day be used by medicine in order to save the lives of patients that find themselves in immediate need for transfer to specialized medical centers.

The advantages of patient transport by airplane, compared to that by other means of transportation have as a result its everyday use for that purpose. Nevertheless, in order to perform an airtrransfer correctly, it is imperative that both the medical and nursing staff be properly educated.

In fulfilling this need, the Nursing Service in cooperation with the Medical Directorate of the Hellenic Air Force General Staff has created a Flight Nurse School.

The purpose of our discussion is to inform you about this school and let you know about its operating procedures, its goals, as well as about the present state of the Airtransfer System in the Hellenic Air Force.

The following issues regarding the operating procedures of the School will be discussed in more detail.

Paper presented at the Aerospace Medical Panel Symposium on "Recent Issues and Advances in Aeromedical Evacuation (MEDEVAC)" held in Athens, Greece, from 3rd to 7th October 1994.

A) Historical background of the School.
B) The aims of the School
C) The Training program

1.1 HISTORICAL BACKGROUND

Before the foundation of the Flight Nurse School, selected persons from the nursing staff followed the courses of the School of Aerospace Medicine, which was operating at the Center of Aerospace Medicine with the aim of educating the medical staff.

The first step was realized in 1984 with the training of a nurse at the "Flight Nurse School" which is located in San Antonio USA. In the years that followed more officer nurses were trained in Brooks Air Force Base in San Antonio. At present, at least one officer nurse is trained each year in the USA.

With the initiative and the efforts of these trained nurses, the Hellenic Flight Nurse School was founded in 1988 following the American standards, adapted to the needs and capabilities of our country.

1.2 THE AIMS OF THE SCHOOL

The ultimate purposes concerning the foundation of the school are:

1) To advance the quality of Nursing Care.
2) To install the minimum demands - standards of care for F.N.
3) To access F.N. nursing enlightenment to all levels of medical personnel.
4) The readiness to respond in every emergency condition, involving air evacuation demands in agreement with an appropriate program.
5) The attachment of education to all F.N.
6) To advance assurance quality with a predetermined procedure.

Trainers of the school are the seven officers (N), which have attended the American School so far and have graduated successfully.

It is mandatory, that all graduates from the Military Officers' Nursing School joining the Hellenic Air Force, attend the Flight Nurse School immediately after their graduation. Until now, 68 officers (N) have been trained. The first class was trained in 1988 - year of the foundation of the Flight Nurse School.

1.3 TRAINING PROGRAM

The courses of the School last 40 days each year and just like the American, the program is divided into two major parts:

1. The theoretical training.
2. The practical training.

1. Theoretical training
This is divided in two sections:

a) **Altitude physiology**, which includes the following subjects: Stresses of the Flight, the G forces, the circadian rhythms, etc., as well as how all this affects each system of the human body in particular.

These courses are being taught by Medical Staff trained in the Aerospace School.

On top of that, the trainees go through the high altitude chamber, in order to gain personal experience on the symptoms of hypoxia.

b) **The Flight Nurse section** which includes:
1) The study and Nursing Care of patients with various diseases during the Air Evacuation, as well as the prompt facing of potential complications that might appear during the flight.

2) Orientation in the C - 130 aircraft which is currently being used for Air transfers in Greece.

3) The setting up of the Air Force Medical Service and the Preflight Mission Planning of Air Evacuations, both in the case of peace and in the case of war.

4) The demonstration of the appropriate supplies and equipment that come with a patient transferred by airplane and the study of their operation.

5) The coping with emergency situations in the C - 130 aircraft as well as survival courses on sea and land.

6) Student's practice on the planning and realization of a mission in a given situation. Students are trained in teams in class before the actual practical training on the C - 130.

2. Practical training
This includes:
1) Orientation in the C - 130 and practice in the configuration of this particular aircraft.
2) Preflight mission planning / Patient enplaning and deplaning
3) Triage exercise in war time.
4) Real flight based on a combat casualty evacuation.

During the flight, students face emergency situations and their readiness to respond is evaluated (i.e. need for a C.P.R., emergency landing, etc.).

The practical training does present some problems, since there are no simulators like the ones of the American School and the exercises are performed in a real C - 130 aircraft in Elefsina. This is definitely a disadvantage, since the time and means for the transportation of the trainees to and from Elefsina have to be determined for each day during the seven days of the practical training.

Today, it is not feasible to perform practical training in survival. Some effort is being made for future addition to

the program of the sea survival which will probably last one week.

The graduation from the school presupposes:

a) A minimum score of 60% on the two written tests of the altitude physiology and the flight nursing.
b) The successful use of supplies and equipment according to protocols.
c) The correct performance of the triage, and
d) The correct inflight patient management in terms of both time and procedure during the real flight.

2. ACTIVITIES

2.1. PRESENT STATE - AEROMEDICAL EVACUATIONS SYSTEM IN GREECE

While commenting on the present state, it is important that we take into consideration that the institution and recognition of the trained Flight Nurses, as well as the attempt to involve them in an area which has been unattainable up to a few years ago, is something very recent for the greek reality.

As has been mentioned above, it was not until 1988 that we managed, after years of efforts of certain people, to train the first class in the newly instituted Flight Nurse School and thus try to put the MEDEVAC system on a new basis.

During peace time, the various services involved in the disposition of a means for transportation are: the Hellenic Air Force (HAF) to the largest extent with the disposition of helicopters and C - 130 Aircrafts, the Hellenic Navy (HN) with helicopters capable of realizing night flights, certain airlines and various private insurance companies that have helicopters for servicing their customers.

Not all MEDEVAC cases are necessarily related to the HAF, which, in the context of social support contributes to the work of the state. The only criteria are the degree of emergency and the location of the case.

Patients are usually transferred from distant areas of the country or islands towards the large urban centers, most of the times Athens and Thessaloniki.

We should mention here that there is no special department for MEDEVACS in any medical facilities (peripheral - dispatching or central - admitting), except for a central service operating in Athens and coordinating all activities related to emergency MEDEVACS. This center, however, is under the authority of the Ministry of Health.

The organizing of MEDEVACS, within the framework of operations of the HAF which is the major coordinator, includes the administration structure, the human resources and the necessary supplies and equipment.

In war time, the functional structure is altered but the HAF maintains its role. Nevertheless, we have to admit that even in peace times, the degree of cooperation of the various departments and services involved is not as high as it should be.

The administrating authority responsible for issuing, receiving and realizing an order does exist; it is the HAF General Staff, the coordinating military units of the HAF, the Air Transfers Squadron, which supplies the C - 130 Aircrafts and the medical offices of the airports from which the departures and landings of these Aircrafts take place.

Trained medical crew for staffing the Aircrafts used for MEDEVACS does not exist. None of the aforementioned services has trained staff and the one that does exist is very hard to become involved.

The ignorance of the basics around the subject of MEDEVACS, the lack of interest to acquire special knowledge and the difficulty to adjust in a new situation where financial parameters are also involved, lead to the disintegration of the efforts with a negative impact on the evacuated patient. These patients are sometimes transferred without the escort of a doctor or a nurse.

There is no specific person responsible for delivering and receiving the patient in the transport stations. A signed certificate of a doctor of the dispatching medical facility who doesn't possess any Aerospace Medicine knowledge is enough for the Medical Evacuation of a patient with an Aircraft. This signature covers the crew typically and legally. The patient though? Who covers his/her problems and needs?

Even in the cases where HAF doctors who have followed an Aerospace Medicine course are involved, ensuring the availability of Flight Nurse is more than difficult.. This happens because there is no predetermined communication and coordination channel throughout the HAF services.

A result of the above is that in most of the cases where the transferred patient is directly related to the HAF (i.e. officers in duty, persons injured within the boundaries of a HAF military unit, etc.) and the presence of the doctor of the military unit is necessary, the routine of his service is disrupted after his departure for the evacuation.

One proposal that has been adopted with a lot of effort is that in war time, apart from the doctor, a Flight Nurse should also be placed in the Air Evacuation Stations (AES), the authorized stations for Air Evacuations that are being developed all over Greece. Nevertheless, it not mentioned anywhere that these Flight Nurses are going to be part of the medical crew of the Aircraft. The use of a doctor or a nurse as escort crew for the Air Evacuated wounded is in the judgment of the officer in charge of the AES. According to No 3204 STANAG issued by NATO though, apart from the other issues mentioned, it is established as obligatory in war time the staffing of

Aircrafts with Flight Nurses and lower rank officers (N) that have studied in a Flight Nurse School.

The existing mentality that in war time our limited number of Aircrafts will be used for the transport of material and not of the injured probably suggests that there is no provision for use of nurses as described above.

As far as the SUPPLIES AND EQUIPMENT section is concerned, I believe that there is also a problem that should be mentioned. There are four sets of supplies and equipment ready in the medical facilities of the 112 Combat Wing (CW) where the Air Transport Squadron also belongs; these were created by Flight Nurses and include the essential medical material.

The provision of certain special equipment is still pending but steps have been taken towards this direction.

Most of this equipment is available in the Flight Nurse School for training purposes and are made available for the transportation of a patient with a special problem whenever they are requested. Perhaps the skepticism does exist as to whether it is necessary to spend a large sum for the provision of material for which the need is not immediate. Nevertheless, the individuality of our country, the subtle balances in the territory and the need for constant alert do not allow for the luxury of last minute decisions. It would be a wrong tactic.

2.2. MISSIONS

With the situation being as described above, it is easy to understand that the possibility for gaining experience through the application of theoretical knowledge is very limited. Of course, there have been missions of the HAF where a Flight Nurse was used, mostly with the initiative of the supervisors of the School and with their personal attendance in most of them.

* MACEDONIA: Activation of a Chinook helicopter with medical and nursing staff for the Air Evacuation of injured after the derailing of a train in a distant area.

* MALTA: C - 130 mission with a Flight Nurse for the Air Evacuation of five greek seamen that were flying with a TWA Aircraft that became the target of a terrorist act.

CONSTANTINOUPOLIS: Mission for the Air Evacuation of injured greek tourists after a fire incident in a tourist bus.

* KALAMATA: Activation of the HAF, in the context of social assistance, for the Air Evacuation of injured after the serious earthquakes, thus contributing to the realization of a plan for the case of massive health disruption in peace time.

* PERSIAN GULF WAR: State of alert of personnel and material, awaiting a potential implication in Air Evacuations, in the context of help to the Allied Forces.

Apart from the above, there has been a limited number of Air Evacuations of individual patients within the greek borders, in which a Flight Nurse was involved. In many other cases though, where a Flight Nurse was not present, several "minor accidents" happened that could have been avoided with her presence. These included loss of test results, destabilisation of patients, not facing several problems that popped up during the flight, or even the canceling of the Air Evacuation due to lack of knowledge of the operation of certain equipment , such as the aspirator. No one thought of turning to the Flight Nurse School. Even within hospital boundaries the Flight Nurse has not been completely established so as to utilize the trained officers (N) accordingly.

The disposition of the people of the School to offer help and information does exist.

2.3. FUTURE GOALS

The majority of the people in Greece, no matter whether they belong to the medical society or not, believe that the Air Evacuation of a patient is not complicated, as long as the disposition of an Aircraft is approved. The existence of the Flight Nurse School and the efforts of the persons involved to convince for the need to review the current situation and involve the Flight Nurses, in order to achieve improvement and harmonization with what is happening on an international level are not widely known.

The steps that have to be followed in order to organize properly the Air Evacuations in Greece are the following:

* Posting 2 - 3 officers (N) in the 112CW -Air Transport squadron- with detachment. These officers will take part in the Air Evacuations and will coordinate the various services.
* Modification of the existing plans by incorporating the staffing of Aircrafts used for Air Evacuations with Flight Nurses.
* The establishment of written criteria and standards to which all Air Evacuations will have to conform.
* The realization of an Air Evacuation within the framework of exercises for the constant training of the Nursing Staff and the resolution of problems that may surface in practice.
* The continuous training of the stretcher bearers for the correct enplaning of the patient.
* The expansion of the training program of the Flight Nurse School in order to include the permanent lower rank officers (N) of the HAF.
* The achievement of cooperation and coordination of the various departments and services involved.

As we approach the year 2000, it is time we stopped wishing and took some time to work seriously and with responsibility with this issue in order to avoid

confusion in the case of strenuous situations. The realization and application of the aforementioned proposals is necessary for our attuning with the activities and standards of all NATO member states in this field.

3. RECAPITATION - EPILOGUE

From what has been mentioned up to now, it is obvious that if Air Evacuations are to be conducted with safety and responsibility, a review of the current state that rules them in our country has to take place.

Greece is the third NATO member state that operates a Flight Nurse School. This was established in 1988 and offers a training which is obligatory for all new Lieutenants JG that join the HAF.

We have to convince people, not only the ones that belong to the HAF but also the authorities of the Ministry of Health, the state and the society, that the presence of a Flight Nurse during an Air Evacuation is necessary.

The care of the patient and the coping with his/her problems will be promoted and the experience that will be acquired through the application of theoretical knowledge will be invaluable.

All of us, the trainers and the people of the School give our own battle to achieve our goals.

The battle that you see here (SLIDE) was won and the patiënts during an exercise of the HAF were transported from Rhodes to Athens and reached their destination safe and sound since the Air Evacuation was performed according to the necessary standards. Nevertheless, the war has not yet been won.

There is a greek proverb saying that "beginning is half of the whole". We hope that we are doing a lot more than a beginning.

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- Coordination

14. Abstract

Recent experience has demonstrated NATO's difficulty in planning and coordinating International Aeromedical Evacuation of acutely sick, injured and wounded patients. There is much discussion which seeks to clarify and define NATO's role in medical air evacuation.

Papers in this Symposium updated available data in medicine research and development and provided a focal point for discussion of specialized equipment and techniques required to care for patients in the NATO Medevac System.

The Symposium covered also the role, training, procedures as well as command and control in the management of casualties in the aeromedical evacuation system.

The new NATO strategy is characterized by high mobility, more flexibility, rapid augmentation and better interoperability.

There is a clear operational need to provide medical planners within NATO and Alliance Nations with a generic concept of integrated aeromedical evacuation to improve the effectiveness of NATO Forces.

The purpose of this symposium was to exchange data experience, and management rationales dealing with the very difficult task of Aeromedical evacuation and to offer recommendations. The goal is to provide a framework for NATO nations to plan for effective seamless aeromedical evacuation in multi-national operations.

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Advisory Group for Aerospace Research and Development
North Atlantic Treaty Organization
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